ANNALS
OF
The Entomological Society of America

Volume XXV SEPTEMBER, 1932 No. 3

THE FOOD PLANTS OF THE LEAFHOPPERS

E. D. Ball,
University of Arizona, Tucson.

The writer's major scientific interest for many years has been in the life histories and food plant relations of the higher Homoptera. The greater number of publications to date have been along systematic lines, not due to interest, but to necessity of naming species before it was possible to publish life history studies of a group. In fact, the first result of an intensive life history study of any given group is usually the discovery that we are dealing with a much larger number of species than had previously been recognized, that these species have definite food plants and that their life histories are very diverse but remarkably well adapted to the development of the particular part of the plants used as food.

Osborn and Ball have shown, for example, that *Dorycephalus platyrhynchus* passes the winter as a two-thirds grown nymph in the base of the wild rye clumps. These adults appear through a considerable time in the late spring. Egg-laying extends over an equal period but no eggs hatch until the wild rye blooms in July, when in a single hour preceding a thunderstorm, eggs in a basement laboratory and eggs in the field all hatched and the little alligator-like nymphs "shinned" up the stems in solid rows and concealed themselves in the glumes to feed on the rich material being stored in the seeds. A single generation occurs over a ten-month life period, extremely long for a leafhopper, all delicately adjusted to the flowering period of its host. On the other hand a near relative feeding on an early blooming plant has two generations and passes the winter as an adult.

Attention has been called to the remarkable adaptation of *Alebra* to a particular food plant, the Japanese maple. In the District of Columbia this species winters in the egg stage under the bark of the young shoots. These eggs hatch with the first signs of growth of this early leafing tree and the adults begin to appear a month later; in another month the eggs are laid. These eggs spend 10 months in a dormant stage in sharp contrast to the 10-month activity of *Dorycephalus*. It also affords an equally sharp contrast to the two generations per annum of an *Erythroneura* of the *maculata* group on nearby sycamores. In this case the first generation appears after the major activity of *Alebra* is over for the year.

In the deciduous forest regions the determination of food plants is a difficult and tedious process because practically all areas have mixed vegetation and the insects scatter when disturbed. The higher plains region is much better because the number of species of plants is reduced and areas of pure stands are frequent. For those wishing to make accurate food plant determinations the arid regions in general are very favorable, and the so-called deserts of the Southwest in particular are veritable meccas. Here isolated clumps are the rule, and areas of an acre to a square mile of practically pure stands abound. A year of careful work in this region will yield more accurate data than can be accumulated in five in the humid regions.

Each additional group that has been carefully studied strengthens the conviction that in general the leafhoppers are specifically adapted to a single food plant or to a small group of related forms and that their distribution is usually more restricted than that of their host. There are, of course, exceptions, some with wide distribution and others with a diversity of food plants; a few with both. These in the latter classes are usually the economic species.

The same thing is true of the grasshoppers, with species running into the hundreds, only five or six general feeders are ordinarily classed as injurious to cultivated crops while a large number are confined to a single food plant and many of these are beneficial because they feed exclusively on weeds or shrubs that are classed as injurious.

While we are far from a complete knowledge of the food plant relations of a single group of leafhoppers much progress

has been made in the last few years. Especially helpful is the fact that many of the erroneous records of the past are being corrected. Much of the work of the past has been done from an economic standpoint and an accidental capture on a crop or forage plant has been recorded, often without noting that it was based on meager evidence.

Still more confusing has been the fact that grass, being the almost universal ground cover of the eastern part of the United States, has been listed as the food of many species that our growing knowledge indicates are strictly confined to other types of plant life either growing above, with, or under the grass cover.

For example, the writer established the subgenus *Paririana* of the *Gyponas* for a group of dead-grass colored species all of which had been taken from nearly pure grass stands. It appeared very certain that the members of this group were all grass feeders. Imagine the surprise upon discovering this season that a low, widely creeping form of mallow (*Sida diffusa*) growing beneath the grass was certainly the actual food plant of one species, while the adaptation in color was to the grass above. Now it will be necessary to reinvestigate the food habits of every other species of the genus.

In another case an author records *Acucephalus albifrons* as abundant and destructive in timothy meadows. While working at Woods Hole, the writer found that this was true, but that the destruction was confined to the plantain growing between the timothy clumps. As plantain appear to be the worst weed in timothy meadows this is undoubtedly a highly beneficial insect. Two writers have stated that all members of the genus *Scolops* of the *Fulgoridae* are grass feeding forms. The food habits of fourteen out of the twenty-four species are fairly well known. Of these eight feed on different species of Compositae, most of them strictly confined to a single species of plant, one on *Ambrosia*, two on *Atriplex*, two on *Dondia* and one on *Stillingia*, a spurge. Information as to the food plants of the remaining species is not conclusive but no indication of grass feeding habits has been found.

This does not mean that there are not large numbers of leafhoppers that are grass feeders for there are some thirty species in the *Dorydiinae*, 100 species in the old genus *Deltocephalus*, 30 formerly called *Athysanus*, 30 in *Athysanella*, 30

in *Chlorotettix*, about 30 species out of the old *Thamnotettix* and 30 in *Cicadula* and its allies that are very largely if not entirely grass feeders, or on grass-like plants, making over 300 in all.

On the other hand some 110 species of *Bythoscopinae* have no grass feeders, 50 species in *Cicadellinae* and *Gyponinae* are certainly not, while there are some grass feeders in *Draeculacephala* and one or two related genera. There are no grass feeders in the 40 species of *Aligia* and *Mesamia*, only 8 out of the 34 in *Scaphoideus* and these have been set off as a separate genus. There are no grass feeders known in the 50 species of the old genus *Platymetopius*, 90 *Phlepsius*, 50 *Eutettix*, 20 *Neocoelidia* and its allies, 20 *Acinopterus* and there are at least 40 *Thamnotettix* that are not grass feeders, making around 500 species that do not feed on grass in addition to practically the whole *Typhlocybinae*, whose fomer modest numbers are rapidly becoming legion. A wag has suggested that their food plants must be *Craetegus* and that they were trying to keep up with the multiplication of species in that prolific genus.

There is another phase of the food plant problem that needs attention. In a number of recent ecological studies the authors have treated insects in the same way that they do plants, referring them to Associations. If we recognize that in the leafhoppers at least the great majority of species are entirely dependent upon the presence of a particular species of plant for their survival then we should recognize their association with that particular plant and not with a group of plants. This particular host may occur only in a transition zone; between associations it may be much more widely distributed or more restricted than any association.

If, however, the host plant relation is recognized then the insects distribution with reference to the host is important, it may only occur in deep shade or in open areas; where the vegetation is rank or where it is sparse; it may be limited to plants adjacent to good hibernating quarters or close to alternate food plants that may tide it over a drought period. There are innumerable relationships of this character that cannot be considered except in relation to the food plant.

One of the largest genera of the treehoppers (*Cyrtolobus*) is strictly confined to the oaks, not even extending to the closely related chestnut and chinquapin but this is exceptional

in the higher Homoptera at least. Frequently a genus will have a major group of species adapted to a single genus of plants or to a group of closely related genera like the *Idiocerus* to willow and poplar but there is usually a smaller number of species rather widely distributed as there is in this case. The other extreme is reached when the members of a genus are widely distributed through the different plant groups as in case of the members of the old genus *Platymetopius*.

There does not appear to be much crossing over in food plants in a given insect genus between Monocotyls and Dicotyls; not nearly as much in fact as between woody-stemmed Dicotyls and Gymnosperms, probably the suitability of the woody parts for egg deposition being a more important factor than botanic relationship. There are a number of different genera in different orders that feed on ferns. This raises an interesting question as to whether this is a persistence of a primitive food habit or a secondary adaptation of recent date. At least one family feeds on fungi in the nymphal stages which adds still greater interest to the same line of speculation.

In conclusion we find (1) that recent additions to the knowledge of food plant relations in the leafhoppers indicate a very definite and restricted food habit for the great majority of species, the few exceptions forming the nucleus of a small group of injurious species. (2) That large groups are almost exclusively grass feeders but that other groups that have been reported as grass feeders have other food habits and that in general all the members of a natural group will be found to be either grass feeders or all of them will have other food habits. It is even probable when more is known that this character can be used as an aid in determining broad relationships and derivations.

AN UNUSUAL OCCURRENCE OF SPIDERS IN NORTHERN FLORIDA.

THEODORE H. HUBBELL,[1]
University of Florida, Gainesville, Florida.

During the fall and early winter of 1931 my attention was attracted by the occurrence of great masses of spider-webs along the west shore of a lake situated about six miles east of Gainesville in Alachua County, Florida. This lake, the site of the biological station of the University of Florida, was formerly called Pithlachocco but now bears the more prosaic name of Newnan's Lake. It is six or seven miles in length, and shallow throughout. Its level fluctuates considerably even in normal years, and the prolonged drought which occurred in the fall of 1931 caused it to lower more than the usual amount, exposing a breadth of sandy and mucky beach beyond the fringe of cypresses which borders the shores and ordinarily extends into the water's edge.

On one or two visits to the lake made in the latter half of September nothing unusual was noted; but when I returned about the middle of October the shore presented an amazing sight. Every object projecting above the ground at the edge of the cypress growth was thickly swathed with spider-webs, completely enveloping the smaller cypresses of the outer zone, and in places even extending up the trunks of the larger trees to a height of ten or fifteen feet. Commonly the webs stretched over and bound together whole groups of young trees, and where an isolated cypress shrub stood out in advance of its fellows it was usually so tightly wound by the white sheet that its branches and twigs were actually bent into conformity with the rounded contour of the mass of web. It is difficult to convey an impression of the weird appearance presented by this array of sheeted forms, stretching as far as the eye could see along the shore of the lake. I estimated that the webs extended in this fashion for a distance of at least three miles.

[1]Contribution from the Department of Biology, University of Florida, Gainesville, Florida.

Closer examination of the webs showed that they were inhabited by enormous numbers of spiders of several species and of various sizes. By far the most abundant was *Tetragnatha seneca* Seeley; *Tetragnatha vermiformis* Emerton was considerably less numerous, and *Epeira strix* Hentz formed a still smaller proportion of the population. These three species appeared to be responsible for the formation of most of the mass of webs; but great numbers of young spiders, probably Epeiras or Theridions, occurred with them, spinning their delicate strands between the heavier threads of the larger webs.

FIG. 1. Spider webs along the shores of Newnan's Lake, Florida.

Pardosa milvina (Hentz), a Lycosid, and *Phidippus variegatus* (Lucas), an Attid, were also rather numerous on the ground beneath the webs and on the bases of the cypresses, together with other less conspicuous forms. These identifications were kindly made for me by Miss Elizabeth B. Bryant of the Museum of Comparative Zoology.

The nature of the food supply of this immense spider population was obvious. The ground, the trees, and even the spider-webs themselves were covered with resting midges, which rose in singing swarms as one walked along the outer edge of the cypress zone. These midges, as determined by Mr. C. W. Johnson of the Boston Society of Natural History, were practically all of the single species *Chironomus lobiferus* Say. So abundant was this food supply that the spiders could scarcely cope with it; their webs were full of entangled midges,

living and dead, that had not been molested. For the most part the spiders remained motionless, apparently replete and lethargic; at intervals one would grasp a Chironomus which had blundered into the web immediately in front of its jaws, or move a short distance to where one was struggling. On an average the spiders were perhaps three inches apart in the webs examined, and while each apparently had its own domain which it did not leave, it was impossible to distinguish where one snare left off and another began in the continuous mesh of threads. Over three hundred spiders were counted in one small isolated cypress shrub about four feet high, about ninety per cent of which were Tetragnathas.[2]

An interesting feature was the abundance in the webs of the beetle *Ceratomegilla floridana* Leng. (*Megilla maculata* of authors). Hundreds of them were seen crawling about among the strands, or grouped in clumps under sheets of web stretched over twigs and branches; the spiders apparently ignored them altogether.

A hymenopterous insect, *Tromatobia zonata* (Davis), was seen in considerable numbers, walking about on the surface of the webs, or crawling through their meshes; Mr. R. A. Cushman, who determined the species, states that it is parasitic within the egg-cocoons of spiders.

The masses of spider-web increased in density and extent until about the end of November, but after a few light showers in early December they lost much of their spectacular appearance, and by the middle of that month only ragged remnants of them remained.

---

[2]This interesting type of spider outbreak appears to be characteristic of certain aquatic situations, those where an enormous number of aquatic insects are regularly concentrated on a limited shore line or on islands. Such an outbreak occurs every year or two on some one of the islands in western Lake Erie, but has not been observed on more than one island in any one year. In 1931 an outbreak occurred on Middle Sister Island and was described to the writer as tents of webs covering trees twenty feet high. This island has many square miles of shallow water about it and is always filthy with dead and dying aquatic insects. About 1923 an outbreak occurred on Pelee Point, Ontario, where a large area of forest undergrowth was tented with spider webs. In 1922 an outbreak occurred on East Sister Island and in 1921 there was an outbreak on the west shore of South Bass Island. The fauna of this outbreak was described by Miss Auten (Ann. Ent. Soc. Amer. 18: 240–250. 1925).—THE EDITOR.

THE SALT MARSH SAND FLY PROBLEM (Culicoides).[1]

W. E. Dove, D. G. Hall and J. B. Hull,
U. S. Bureau of Entomology.

This paper is a preliminary report on blood-sucking midges occurring along the Atlantic and Gulf Coast littorals. It outlines our knowledge and methods of attack on this important insect problem. It is made with the hope that we may stimulate interest and enlist the cooperation of entomologists and others in our work.

HISTORICAL.

In literature the name "sand fly" is used principally for the genus *Phlebotomus*. Many references are made to the occurrences of these midges in localities about the Mediterranean Sea. In our own country the layman applies the term to all biting midges occurring along the seacoasts. In the latter respect it includes *Culicoides*, *Leptoconops*, certain *Psychodidae*, and others. At times the layman uses the name for non-biting flies which breed in fertilized flower pots and for the eye-gnat, *Hippelates*. Less frequently it is applied to deer flies (*Chrysops*) and to stable flies (*Stomoxys calcitrans*). Since the name is in common use for the biting midges of the seacoasts of this country, and since some of these midges are about the size and color of grains of sand, we wish to retain the use of this name. In the present report the term "sand fly" is used for the species of *Culicoides* which occur about salt marshes and brackish water areas. For descriptions of these and other species of *Culicoides* we wish to refer to Hall (1), the revision made by Hoffman (2) and to subsequent studies made by Root and Hoffman (4). For descriptions and records on the immature stages of the tropical sand fly *Culicoides furens* Poey, reference is made to the studies of Painter (3) in British Honduras.

---

[1]Contribution of the Division of Insects Affecting Man and Animals, Bureau of Entomology, United States Department of Agriculture.

Read before the twenty-sixth annual meeting of the Entomological Society of America, New Orleans, La., December 30, 1931.

Sand flies are not new pests of the Atlantic Coast of North America. The history of the Creek Indians (6) reports that the natives made smudges and placed them beneath their beds in order to drive away the biting gnats. History records also (7) that during an escape down the east coast of Florida, Confederate soldiers were forced to walk along the beaches. The biting gnats and mosquitoes were so annoying to them that the soldiers were obliged to cover their bodies in the sand and use clothing for the protection of their heads. From such reports and from personal experiences with sand flies, we share with Mr. W. I. Fee, of Fort Pierce, Fla., the opinion that these biting insects were largely responsible for the lack of early development of the southern areas of the Atlantic Seaboard.

ANNOYANCE.

Sand flies are felt before they are observed. The sensations due to their bites are not as painful as those caused by bites of some mosquitoes, but they bear some resemblance to gentle pricks of nettles on the skin. Following the bites, some individuals experience burning sensations and desire lotions for relief. The lesions resulting from the bites may appear as wheals and subsequently they may persist for several days. Due to the movement of these insects on the skin one often responds to the itching by scratching. In this way the skin may become irritated and hypersensitive. This is most noticeable in children and persons who are not familiar with these pests. Persons throughly familiar with the bites simply brush their hands over the feeding sand flies so as to crush them on the skin. Some of these persons are residents who seem to possess a degree of immunity to the bites, or ones who seem determined to minimize the effects of the bites. It has been our observation that even though a most resistant native smokes for self-protection, he is obliged to retreat from large numbers of hungry sand flies. We recall one instance of an escaped convict who successfully evaded the highway police, but was forced to "give up" to these authorities. According to him he was unable to withstand the punishment of the sand fly bites.

Sand fly annoyance is affected by temperatures and wind. Different species of sand-flies occur during different seasons when there are different atmospheric temperatures, but each

species is most annoying to man when there is no breeze. At such times the thermotropic responses are marked. Animals having a high body temperature attract large numbers of the females. The heat emenated from a closed automobile or the heat obtained from sunlight on the side of a building are especially attractive to them. Some of them come to lights and are found on the walls nearby. These observations lead us to believe that the heat radiated from a man at physical labor is largely responsible for the unusual annoyance received by him. Such men are inclined to attribute the annoyance to digging in the soil, mowing a lawn, collecting oysters, rowing a boat, painting a house, or some other particular type of exercise.

It is not a simple matter to evade sand flies. They usually take blood from those portions of the skin which are not protected by clothing but they feed readily through hose or other thin clothing. They are capable of crawling beneath the clothing. Quite often they get into the hair of the head and work their way to the scalp, where they become extremely annoying. They feed during the daylight as well as at night, and are capable of going through very fine meshes of screen. When cloth is used on windows to prevent ingress of the flies into rooms, it prevents a much desired circulation of air. Temporary relief may be obtained by the use of a repellent on the skin or window screen, by use of a smudge, or by taking refuge in a tightly closed room. Tourists sometimes find that the best means of prevention is obtained by moving to a locality where sand flies do not occur. This means that the tourists do not spend much money when and where sand flies are encountered.

ECONOMIC IMPORTANCE.

During recent years, and particularly since the advent of the automobile, resorting has become a big business for our coastal areas. In efforts to share the profits of this new business different localities have attempted to capitalize on their delightful climates, the scenic beauty of their rivers and inlets, the lures for fishing and the quiet waters for yachts and other small boats. Some of these localities are highly successful during seasons when sand flies are not abundant. Others, not so fortunate in their locations, experience difficulty in securing a stable business. Still other areas with natural attractions for tourists are aware of the pitfalls caused by the occurrence

of sand flies and other insect pests of man, and are not yet attempting to develop their waterfront properties. It would be unfair to mention localities having hotels and residences which were vacated, or to mention persons who were obliged to dispose of pleasure boats because of sand fly annoyance. For the owners of waterfront properties we hope to assist and determine means of control of these pests. We find that such persons realize that they have a problem and they are anxious to face it with control measures, but they do not wish to give the matter publicity.

INCIDENCE.

Localities about fresh water inlets of the seacoast and on streams leading to these inlets are places where sand flies are most numerous. Such places hold natural attractions for tourists and resorts as well as for sites for residences. The quiet waters hold charm for persons admiring natural beauty. During the cool temperatures of spring and autumn when one delights in going on the rivers and about the marshes, the "larger sand flies" (*Culicoides canithorax* and others) are most abundant. During the higher temperatures one is apt to feel the "yellow ones" (*Culicoides melleus* and others) and the "little gray ones" (*Culicoides dovei* and others). Different species have rather definite periods of emergence but these periods sometimes overlap. In the more northern localities sand flies disappear during the winter months, but at other times of the year they may be found in varying numbers. In subtropical localities when there is little or no breeze, one may encounter some of them during any month of the year.

METHODS.

In searching for breeding places of sand flies two methods were used. One consisted of taking samples of water, silt and decaying vegetation in attempts to secure larvae. The other made use of cages over locations suspected as breeding places of sand flies.

The "recovery cages" were made square with inside measurements of 24 inches, by 12 inches high (Fig. 1). They were covered with black Indian Head cloth to prevent escape of the flies. The cloth was protected from animals and mishaps by a cover of hardware cloth. The two covers were securely fastened

to the cage with strips of wood molding. At the center of one side of the cage the rim of a glass jar top was tightly fitted into a hole so that it would support a standard pint size fruit jar. When a jar was fitted in this manner it collected the sand flies which emerged from the soil beneath the cage. The flies were attracted by the light of the jar opening and were collected in the jar. When these cages were placed about ditches and marshes reached by the tides it was necessary to drive stakes

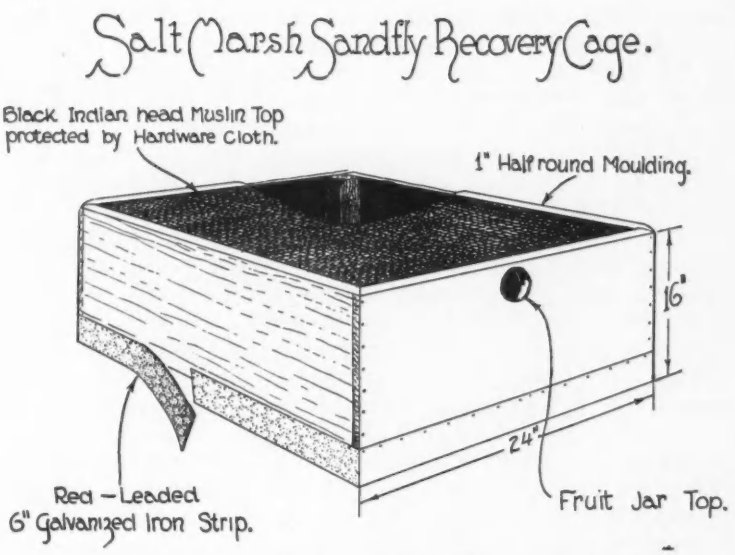

Salt Marsh Sandfly Recovery Cage.
Black Indian head Muslin Top protected by Hardware Cloth.
1" Half round Moulding.
16"
24"
Red – Leaded 6" Galvanized Iron Strip.
Fruit Jar Top.

FIG. 1. Cage used for the recovery of sand flies emerging from soil.

beside them and to nail them to the sides of the cages. The cages anchored in this way were quite satisfactory in obtaining emerging sand flies. They furnished records on places where sand flies emerge and on the periods of time these infested areas were capable of producing sand flies.

During preliminary attempts to secure sand fly larvae, use was made of the Banta collecting pipettes. The water in fiddler-crab holes was thoroughly agitated and samples were transferred to glass jars. In this manner samples were obtained from 10 to 25 crab holes in each quart of the material. These

samples were carried to the laboratory and the silt was allowed to settle to the bottom of the jars. With a light it was possible to recognize the sand fly larvae by the characteristic swimming movement. With a small pipette the larvae were "fished out" and transferred to dishes. This method of recovery was efficient but it entailed a large amount of labor.

A satisfactory method of recovering sand fly larvae from muck samples was devised. It takes advantage of the migratory habit of the larvae. An evaporating dish containing the muck sample is placed into a larger dish, and tap water is added until the sample and smaller dish are completely submerged (Fig. 2). Within about three days the larvae migrate to the edge of the larger dish and are trapped in the moat of water. By means of a pipette they are easily transferred to dishes.

In determining the hydrogen-ion concentration of samples, use is made of a colorometric method having standard indicators and buffer solutions.

The salinity of muck samples is tested by means of a titration described by Sinton (5). It makes use of a pipette or burette graduated to 1/10 cc, a 50 cc. beaker, a small dropping bottle containing a saturated aqueous solution of potassium chromate, and a brown bottle containing a solution of silver nitrate. The latter solution is prepared by dissolving 9.48 grams of pure recrystallized silver nitrate in 1,000 cc. of water. To 2 cc. of the water to be tested one adds two drops of the chromate solution. To this one gradually adds from a pipette the solution of silver nitrate. There is no permanent change of the yellow color until all of the chlorine of the sample is changed to silver chloride. When this is accomplished there is a permanent red coloration. The number of cubic centimeters required to obtain the end point is multiplied by 100. The result is the number of parts of free chlorine in 100,000 parts of water. Sea water tests approximately 2,000 parts in 100,000.

A standard sample for sand fly larvae consists of one quart of muck taken from an area one foot square. This represents a depth of much less than one inch. When samples are taken from crab holes we measure the amount of soil in terms of quarts and record the number of holes represented in each quart. Records are made on the fauna, flora, the presence or absence of hydrogen sulphide, the approximate per cent of shade during the day, the type of soil, and the evidences of

tidal action. In the laboratory the sizes and number of larvae obtained in the samples, the pH, and the salinity are determined.

For preservation of adult sand flies a mixture is used of 80 parts of 95% alcohol, 15 parts of 10% formalin, and 5 parts of pure glycerine. Some male specimens are collected about lights, but most of them are obtained from dances near the edge of the marshes. These are often near the ground, but may be as high as about six feet. Small numbers of females visit the dances, making it appear that this habit is a mating process.

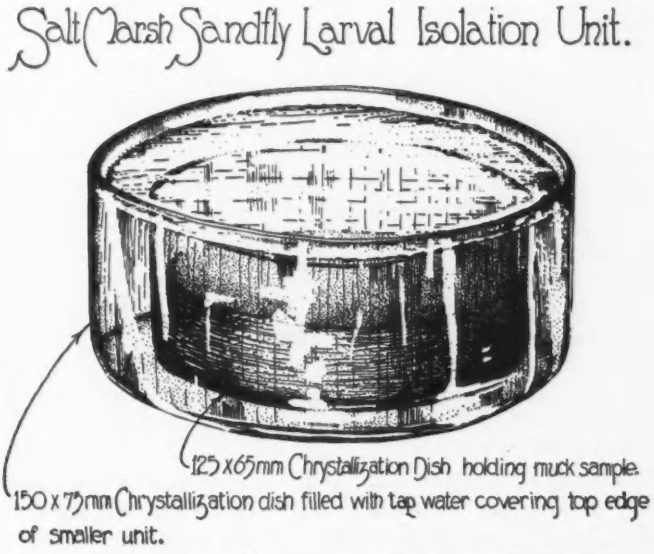

Salt Marsh Sandfly Larval Isolation Unit.
125 x 65mm Chrystalization Dish holding muck sample.
150 x 75mm Chrystallization dish filled with tap water covering top edge of smaller unit.

FIG. 2. Crystallizing dishes used for the isolation of sand fly larvae from soil samples.

RANDOM SAMPLING FOR SAND FLY LARVAE.

Collections of soil from different moist locations of the marshes did not always furnish sand fly larvae. Of 589 quarts, 175 gave negative results. In no instance could we obtain larvae from marshes affected by the daily tides. The 414 positive samples furnished 5,684 larvae. An analysis of the locations furnishing these larvae shows that the shady places

were most favorable. From locations having 75 to 95 per cent shade, 39 quarts of soil furnished 840 larvae or an average of about 21½ larvae to the quart. From locations having 50 to 75 per cent shade, 8 quarts gave 148 larvae or an average of 18½ to the quart. From locations having 25 to 50 per cent shade, 30 quarts of soil furnished 496 larvae or an average of 16½ to the quart. From locations exposed to sunlight, and those having 25 per cent shade during the day, 89 quarts of soil furnished 698 larvae or an average of practically 8 to the quart. From these data it is seen that greater numbers of larvae were obtained from places in the shade. (Table 1.)

TABLE 1.

THE INCIDENCE OF SAND FLY LARVAE IN RELATION TO SHADE.

Per cent Shade	Quart Samples	Number Larvae	Average ± per Quart
0–25	89	698	8
25–50	30	496	16½
50–75	8	148	18½
75–95	39	840	21½
Dense (A)	30	1,498	50

Concentrations of larvae of various sizes, with as many as 165 to a quart sample. Salinity, 2–3.9%; pH 6.5–7.

Collections of larvae made in the open marshes from crab-holes in short grass, tall grass, and pickle weed suggest that the short salt marsh vegetation receiving only the action of the unusually high tidal waters and rainfall had more larvae than did the tall grasses of these areas. Of 12 quarts taken from pickle weed there were 95, or an average of practically 8 to the quart. Of 426 quarts taken from short grass there were 3,135, or an average of almost 8 larvae to the quart. Of 46 quarts taken from tall grass, there were 67 larvae or an average of about 1½ larvae to the quart. (Table 2.)

From the random samples the salinity was found to vary from about 1,500 parts in 100,000 of water to as much or more than that found in sea water.

Of 204 quarts of samples having a pH above 7.0, there were 1,924 larvae, or an average of about 9½ to the quart. Of 25½ quarts having a pH below 7.0, there were 379 larvae, or an average of practically 15 to the quart. These figures suggest that acidity tends to favor the welfare of larvae.

EVIDENCE OF CONCENTRATIONS OF LARVAE.

Shortly after sand fly larvae were found in fiddler-crab holes, we learned that the unusually high tides caused a marked variation in the numbers of larvae present. From October 10th to 20th, 1930, six collections represented by 36 quarts

TABLE 2.

THE INCIDENCE OF SAND FLY LARVAE IN RELATION TO VEGETATION OF MARSHES.

Type	Quart Samples	Number Larvae	Average per Quart
Pickle Weed	12	95	8
Short Grass	426	3,135	8
Tall Grass	46	67	1½
Blind Ditches	16	446	28

of muck were taken from crab holes of a short grass marsh. This area was located within 50 feet of a large shade tree. A total of 201 medium size to full grown larvae were recovered. Thirty-six samples taken from the tall grass and from locations more distant from the shade tree, furnished only five larvae. Following the collections made on October 21st and 22nd, a wind and rain caused water to cover these marsh areas. On October 24th to 29th the unusually high tides of the month again covered the same areas. From October 25th to 31st, 30 quarts of muck collected from this short grass marsh gave a total of 765 larvae, or an average of 25½ larvae to the quart. The same number of samples from the more distant locations in medium and tall grass furnished a total of only 46 larvae. The increase of almost four times as many larvae in these locations is attributed to disseminations from densely shaded areas. (Table 3.)

When a method was devised for obtaining larvae from samples of soil saturated with water, we were able to make comparative studies on soil conditions. When samples were collected from areas protected by shade trees and having accumulations of decaying humus, we encountered concentrations of sand fly larvae. They ranged in number from 31 to as many as 165 in a single quart size sample. Such isolations gave *small larvae* as well as the larger ones. Collections made at various places where shade trees protect decaying vegetation also furnished large numbers of larvae. In 30 quarts of samples from 11 locations, 1,498 larvae, or an average of about 50 per

TABLE 3.

THE INCIDENCE OF SAND FLY LARVAE IN RELATION TO "SPRING TIDES."

Collections 50 Feet From Trees	Quart Samples	Number Larvae	Average ± per Quart
(A) Short Grass.....	36	201	6
Tall Grass.....	36	5	.....
(B) Short Grass.....	30	765	25½
Tall Grass.....	30	46	1½

(A) Before tides and rainfall. (B) After tides and rainfall.

quart were obtained. (Table 1.). Due to the autumn emergence of the common South Carolina species, the average number of larvae recovered is probably low.

The salinity of these locations usually varied from 2,000 to 2,300 in 100,000 parts of water. Just before these places were covered by high tides and following evaporation by the sun, the salinity tested as much as 3,930 in 100,000 parts of water. There was almost twice as much salt in these areas as that found in sea water. In such areas the hydrogen-ion concentrations were found to vary from 6.5 to 7.0. The acid condition of these places was comparable to that encountered in previous collections of larvae.

The finding of concentrations of larvae in densely shaded areas at the edges of the grass marshes, and the occurrence in these of small sand fly larvae, could mean only that such locations are breeding places of sand flies in the vicinity of

Charleston, S. C. (Plate I.) The occurrence of very small larvae just at the close of the seasonal activity of *C. canithorax* strongly suggests that these places are favorable for the breeding of this species. The concentrations suggest that larvae found in locations of marshes near such trees were disseminated by rainfall or by unusually high tides. Our findings on concentrations of larvae demonstrate a type of breeding media. (Table 4.)

It will be interesting to learn to what extent different species of sand flies will require these breeding conditions.

TABLE 4.

Concentrations of larvae were found beneath trees at edge of grass marshes above usual daily tide lines but reached by unusually high tides,

—WITH—

1. Constant Moisture.
2. Cool Temperature of Soil.
3. Dense Shade.
4. Decaying Leaves.
5. Acid Media.
6. Salinity approximately that of Seawater.

DRAINAGE DITCHES AND SAND FLY LARVAE.

Since ditches are used effectively for drainage of marshes and for ingress of top-minnows (*Gambusia*) in control of mosquito breeding in salt marshes, one naturally questions the effects of ditch drainage on development of sand flies. Our preliminary experiments show that sand fly larvae occur on ditches which do not drain. Of 16 quarts of soil collected about the openings of fiddler crab-holes in a "blind" ditch, there were 443 larvae, or an average of about 28 to each quart of soil.

In order to determine if larvae occurring in crab holes and elsewhere on drainage ditches produced sand flies, 24 cages were used on one system of drainage. The cages were located near the edge of the water of the ditches. The salinity of these places varied from 10 to 530 parts in 100,000 parts of water. Where the salinity was low it was not sufficient to prevent growth of fresh water vegetation. Near the terminals of the small laterals there was no visible evidence of tidal water except during the unusually high tides, which occurred

only a few times during the year. From 12 of the cages located on the primary ditches there was no emergence of sand flies. In 12 of the cages located on the laterals and in places which permitted water to collect and seep into the ground, sand flies emerged during the spring months. In three of them, sand flies emerged during a period of 5½ months. Two of the latter cages possessed fiddler-crab holes, and the third was kept moist by a flow of fresh water. Since the 12 cages produced only 111 sand flies, the ditches do not appear to be primary breeding places of large numbers of sand flies. They apparently represent conditions which collect larvae washed from other locations. In them one finds that holes dug by fiddler-crabs serve as reservoirs for water and that these are favorable for the protection of sand fly larvae.

Recovery cages were used also on the banks of a primary ditch where there was decaying vegetation protected by shade. From these locations sand flies were not reared. Coincident with the presence of the ditch which permitted "in and out" flow of daily tidal water there was no evidence of sand fly breeding. These preliminary tests suggest that following high tides and rainfall, the main drainage ditches are efficient in dispatching sand fly larvae to deep water.

CONCERNING THE LIFE CYCLE OF SAND FLIES.

During cool temperatures sand fly larvae have an unusual longevity. Larvae more than one-half grown were kept in the laboratory for periods varying from four to six and one-half months. They were supplied with decaying grass roots and humus in brackish water. Both *Culicoides canithorax* and *Culicoides dovei* were carried over the winter in this way, and some of each species pupated and produced adults during the spring months. This media was the only one which enabled us to rear any adult sand flies. When larvae were kept at low temperatures and were supplied with brackish water twice each week, they lived from three to five months but did not pupate. When kept in a refrigerator at about 50 degrees F., they were alive after a period of six months. The cool temperatures appeared favorable for the larvae.

Sand fly larvae did not withstand the natural atmospheric temperatures of the summer. When those more than one-half

grown were kept in water where the atmospheric temperatures were about 90 degrees F., they lived for only a few weeks. Frequent changes of brackish water did not materially increase the longevity. When there was evidence of a high bacterial growth in the media they lived for only a few days. When exposed to direct sunlight they died within a few minutes. Since, in more than 200 attempts with larvae at temperatures between 70 and 90 degrees F., not a single adult was reared, we are forced to the opinion that warm temperatures are not favorable for the sand fly larvae commonly found in the vicinity of Charleston, S. C.

In recovery cages placed on marshes receiving seepage water during high tides, adult sand flies emerged during periods of more than five and one-half months. Individual records on these cages show that the greatest number of adults emerged from marshes having a short grass. In such locations seven cages furnished 936 adults, or an average of 138 to the cage. In pickle weed areas twelve cages furnished 17 adults or about 1½ to the cage. In the tall spike grass six cages furnished 27 adults or an average of 4½ to the cage. In such places the temperatures were often cold enough to be uncomfortable to the feet of one wearing rubber boots.

The increased longevity of sand fly larvae during cool temperatures and the pupation with emergence of adults following such temperatures can mean only that the conditions afforded by these temperatures were favorable in the life cycle. Since the well developed larvae were not capable of withstanding natural atmospheric temperatures of the summer, we are obliged to accept the periods of larval stages during cool temperatures as being somewhat normal. These periods suggest that larval development may last at least six months, if not an entire year. The long periods of larval longevity, the ability to recover larvae from the marshes during any time of the year, and the appearance of great numbers of sand flies during low atmospheric temperatures, furnish evidence that larvae can await conditions which are favorable for pupation and emergence of the adults.

The pupal period for sand flies lasts for only four to seven days. Under laboratory conditions the adults live for only about ten days or less. Since these flies require three to four

blood meals before they deposit eggs, the maximum longevity in nature is undoubtedly longer than ten days.

At Charleston, S. C., adults of *Culicoides canithorax* predominate during autumn and spring. Just at the close of each of these seasons one finds concentrations of various sizes of larvae in decaying vegetation of the shaded areas. These seasonal concentrations suggest that it is not too much to anticipate natural or chemical treatments of the breeding places.

NATURAL AND CHEMICAL TREATMENTS FOR CONCENTRATIONS OF SAND FLY LARVAE.

Other than by dispersion of larvae in drainage ditches, two methods of control appear to be applicable in destroying the concentrations of sand fly larvae. One is a chemical treatment and the other is the natural drying of the decaying humus.

Some observations on drying were made on a suitable marsh having decaying humus protected by shade. In early collections it was found to possess concentrations of larvae. During this summer the lack of rain and the presence of an offshore wind during a high tide period allowed the surface of the decaying vegetation to become dry. Of 22½ quarts of soil obtained from places having the greatest amount of moisture, there were 205 larvae, or an average of 9 to the quart. About 50 feet from this area 27 quarts of soil from fiddler-crab holes furnished 75 larvae, or an average of about three to the quart. On the other side of the river where similar breeding areas were kept moist by tidal and other waters forced on the marsh by the wind, collections of soil samples furnished from 75 to 161 larvae to a quart. These observations suggest that drying out of breeding places of sand flies effects a natural destruction of the larvae. They suggest that cutting or trimming of trees on the edges of the marshes so as to permit sunlight and drying of accumulations of decaying vegetation might be expected to effect a rather permanent reduction in sand fly breeding.

In laboratory tests for suitable larvicides it was learned that destruction of the larvae could be expected from contact insecticides soluble in salt water. Paris green and oil films had no visible effect on the larvae. Some of the by-products

obtained from the fractional distillations of hard-wood tars appeared promising. The junior author found that a waste product obtained during the process of creosoting pine timber was toxic to sand fly larvae. This product is extracted when the timber undergoes a vacuum treatment with coal tar creosote oil. It consists of water and pine sap with a small amount of creosote oil. It is obtained from a catch basin used for the recovery of creosote oil after the latter settles to the bottom. It tests from one-fifth of one per cent to three-fourths of one per cent of phenols, and is known to us as creosoted pine sap. In a large number of laboratory tests with sand fly larvae it gave a complete and immediate kill in dilutions of 1 to 1,500. Within two hours it gave a complete kill in dilutions of 1 to 2,500. Since this product contained pine resin like Panama oil, we attempted to use it with crude carbolic acid. It was learned that one part of crude carbolic acid would mix with nineteen parts of this product and that the mixture would give a complete kill on sand fly larvae in dilutions of 1 to 10,000 parts of salt water. On mosquito larvae it gave a kill in much greater dilutions. The mixture was inexpensive in that the cost was only that of the crude carbolic acid, which was purchased locally at 88 cents per gallon. Since one gallon of the acid was sufficient to make 20 gallons of the mixture, the phenolized pine sap water was produced at a cost of four and four-tenths cents per gallon.

Two tests were made on a marsh location furnishing concentrations of sand fly larvae. The areas were sprayed so that 50 gallons treated an area of 12,000 square feet. Before the first test was made samples from the area showed an average of 82 larvae to the quart. Within 24 hours the treated area was covered by a high tide. During the following month, 25 quarts of muck samples furnished 191 larvae, or an average of about 7½ larvae to the quart. At the end of this period the area was given a second treatment, using the same rate of application. During the following month, 31 quarts of soil furnished a total of 81 larvae, or an average of about 2½ larvae to the quart. At this time an area used as a check was found to have an average of approximately 60 larvae to the quart. We interpret these preliminary tests to mean that the phenolized pine sap is promising as a treatment for concentrations of sand fly larvae.

Creosoted pine sap without the addition of phenols appears to have a range of usefulness. For control of fleas, mites and various species of fly larvae it holds promise. Since it possesses germicidal properties, has a pleasant odor, and is most inexpensive, its usefulness should meet with popular favor. The junior author is extending these studies and will publish on them at a later time.

GENERAL CONSIDERATIONS.

The evidence on breeding places of sand flies shows that early development of the larvae commonly found at Charleston, S. C. takes place in densely shaded areas at the edge of grass marshes. These locations have decaying leaves and humus which are protected from the heat of the sun. (Plate I.) In these places concentrations of larvae are reached by brackish water of the unusually high tides. Since these tides and drainage from rainfall cause disseminations of the larvae to low areas and into fiddler-crab holes, any treatments for destruction of the larvae should be made before dispersions of the larvae take place. In the vicinity of Charleston, S. C., the most opportune time appears to be in the autumn or late spring, just after the season of sand fly activity. At such times it appears practicable to use a treatment of phenolized or creosoted pine sap near towns, residences and resorts. Since a degree of control might be expected also for salt marsh mosquitoes, the treatment carries a dual purpose appeal.

The concentrations of larvae about the edges of marshes suggest that there are also other means of attack for control of sand flies. One thinks immediately of elimination of the shady breeding places, of drainage of areas having decaying humus, of drainage of areas receiving seepage water containing salt, and of reclamation of marshes beyond the tree lines. Such measures appear to be in line for permanent control of sand flies. To what extent they may be used will depend upon costs and the benefits to be derived.

Along the Atlantic seaboard and Gulf Coast one finds two types of salt marshes, one with growths of marsh grass and the other with dense growths of mangrove. In the state of Florida there is a gradual transition from the grass to the mangrove marsh, some localities having a mixture of the two types.

The studies herein reported are concerned with breeding places of sand flies where the grass type of salt marsh is encountered. In the future we desire to extend our studies to mangrove marshes and to the more tropical species of sand flies.

SUMMARY.

1. In this paper the term "sand fly" is used for the species of *Culicoides* which occur about salt marshes and brackish water areas.

2. The annoyance due to the bites of sand flies affects tourist business, resorting and development of waterfront property.

3. A method is reported for obtaining sand fly larvae from soil samples.

4. In the grass marshes of the upper Atlantic coasts, the early development and concentrations of sand fly larvae were found in decaying humus of the densely shaded areas occurring at the edges of the marshes.

5. Random sampling suggests that sand fly larvae are dispersed by unusually high tides or by surface drainage following rainfall to various places in the marshes.

6. Collections for larvae and attempts to rear adult sand flies from the edges of ditches in salt marshes suggest that those ditches which permit "in and out" flow of daily tides are effective in dispersing of sand fly larvae. They suggest that ditches not suited for control of breeding of mosquitoes tend to accumulate sand fly larvae and aid in sand fly breeding.

7. The period required for development of sand fly larvae of salt marshes is not definitely known, but from records it appears to last from six to twelve months.

8. Drying of decaying leaves, either by drainage ditches or by trimming shade trees near the edges of grass marshes might be expected to reduce breeding of sand flies.

9. Phenolized pine sap is a promising larvicide for treatment of areas having concentrations of sand fly larvae.

10. Salt-marsh conditions afforded by mangrove swamps are not included in the scope of the present study.

LITERATURE CITED.

(1) **Hall, D. G.** 1932. A New Biting Culicoides from Salt Marshes. Proc. Ent. Soc. Washington, 34: 88–89.

(2) **Hoffman, W. A.** 1925. A Review of the Species of *Culicoides* of North and Central America and the West Indies. Amer. J. Hyg. 5: 274–301.

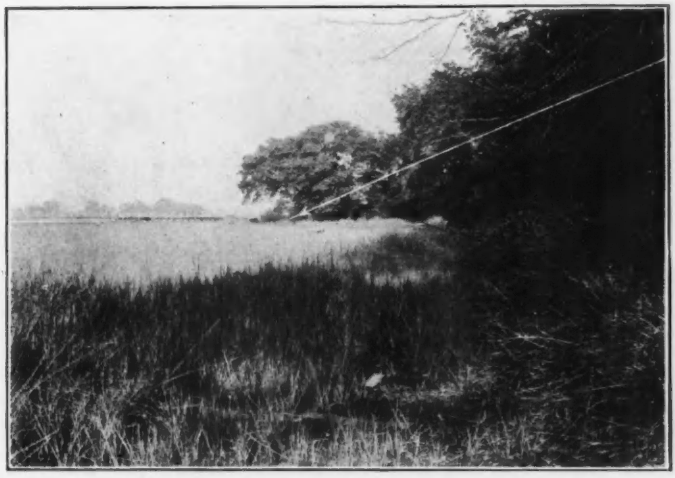
(3) **Painter, R. H.** 1926. The Biology, Immature Stages, and Control of the Sandflies (Biting Ceratopogoninae) at Puerto Castilla, Honduras. Am. Rep. Med. Dept. United Fruit Co., 1926: 245–262.

(4) **Root, F. M.** and **Hoffman, W. A.** 1931. (Personal Communications.)

(5) **Sinton, J. A.** 1930. A Field Method for the Estimation of the Salinity of the Water in Mosquito Breeding Places. Malaria Survey of India, Kasauli, 1930.

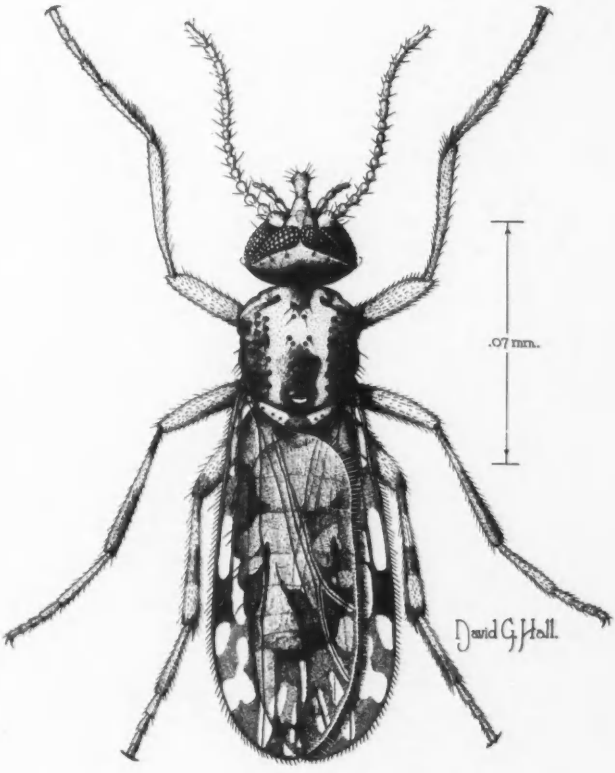
(6) **Swanton, John R.** 1922. Early History of the Creek Indians and their Neighbors. Smith. Inst. Bull. 73: 354. (Extract from *Histoire de la Floride francaise* by Paul Louis Jacques Gaffarel, Paris, 1875: 461.)

(7) **Woods, John Taylor.** 1893. The Escape of the Confederate Secretary of War. Century, 1893: 112.

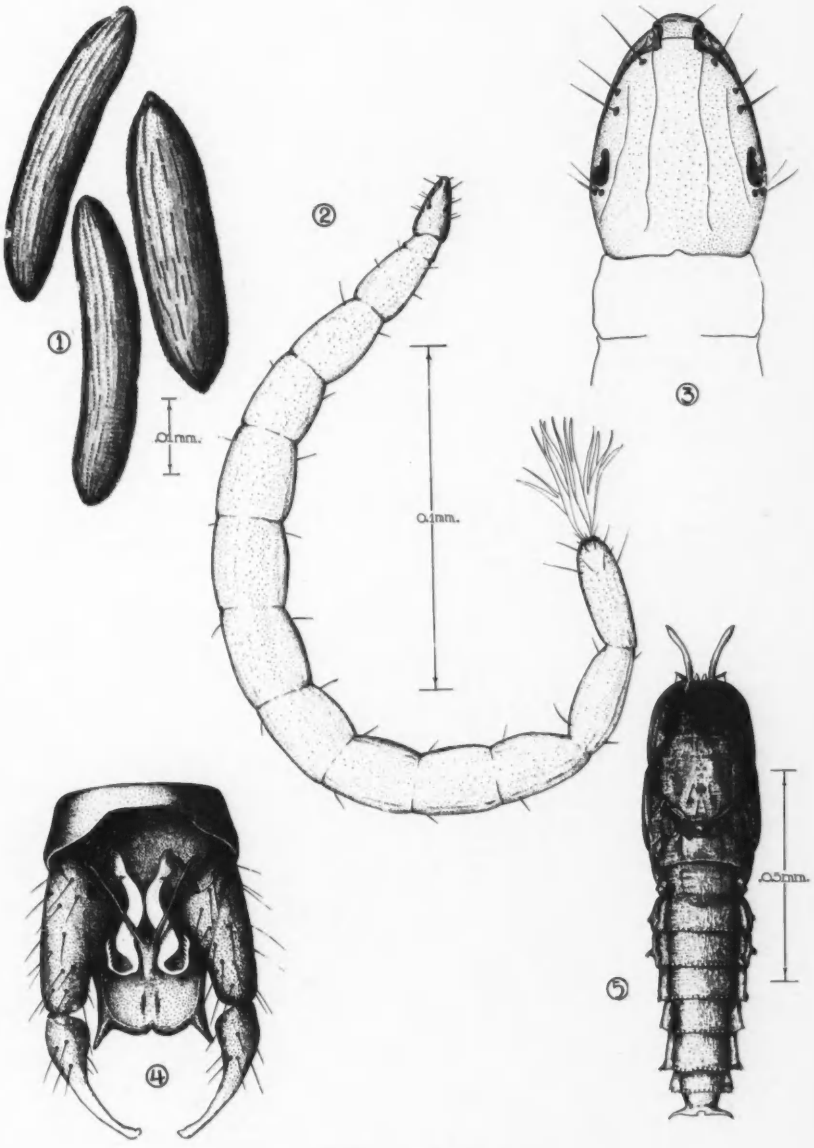


A distant view of a salt marsh showing the "tree line."

A "close up" view of trees on the edge of a salt marsh showing the location of concentrations of sand fly larvae.



Culicoides dovei Hall, the little gray sand fly, adult female.



Culicoides dovei Hall.

1. Eggs. 2. Larva. 3. Head. 4. Male genitalia. 5. Pupa.

A REVISION OF THE CLYTINI OF BOREAL AMERICA, (CERAMBYCIDAE, COLEOPTERA).

Part I.

GEO. R. HOPPING,
Entomological Branch, Department of Agriculture,
Ottawa, Ontario.

CONTENTS.

PAGE

INTRODUCTION 529
CHARACTERS OF THE TRIBE CLYTINI 530
GENERIC SYNONYMY 530
GENERIC KEY 533
THE GENUS XYLOTRECHUS 533
THE GENUS NEOCLYTUS 546
THE GENUS EURYSCELIS 560
THE GENUS CLYTUS 561
THE GENUS TRIODOCLYTUS 565
THE GENUS CLYTOLEPTUS 566
BIBLIOGRAPHY 567
PLATES 569

Since the last revisional work on the Clytini by Colonel T. L. Casey, many new species have been described, and the validity of some old species, which was doubtful, has been verified. There has been some confusion with regard to the sexes of certain species which has been clarified during recent years. It is, therefore, hoped that this revision, with the consolidation of notes and the work of previous writers, will be welcome at this time.

The Clytini group comprises some of the most variable species of any division of the Cerambycidæ. Not only is there individual variation, but in several cases there is surprising sexual variation. In such cases, the sexes have been dealt with separately in the keys, and figures made of each.

In preparing the specific keys, it was necessary to use the elytral markings to a considerable extent. With the Clytini this cannot well be avoided, and, although the elytral markings are somewhat variable, they have certain characteristics which are more reliable than many characters used in the past, such as ground color, and color of the fasciæ. It was, also, necessary in the keys to place some species out of their natural order from the standpoint of relationship. The order in which

they appear in the discussion of species is thought to be the more logical arrangement.

Anyone who has not seen the type cannot establish a synonym to a certainty. In cases where synonyms have been established by the writer, when it was impracticable to study the types, as complete notes and comparisons as possible have been obtained from other coleopterists, who have kindly examined the types. The synonymy indicated is, therefore, the result of careful consideration of these notes combined with a knowledge of the possible variation within the species.

Sincere appreciation is extended to the following entomologists for their kind assistance in supplying specimens and notes: Mr. H. C. Fall, Tyngsboro, Massachusetts; Mr. Charles Schaeffer, Brooklyn Museum; Mr. C. A. Frost, South Framingham, Massachusetts; Professor R. H. Beamer, University of Kansas; Mr. Warren Knaus, McPherson, Kansas; Mr. Charles Liebeck, Philadelphia; Mr. E. R. Leach, Piedmont, California; Mr. F. A. Sheriff, Melrose, Massachusetts; Mr. G. A. Hardy, Provincial Museum, Victoria, B. C.; Mr. W. T. Davis, Staten Island, New York; Mr. H. S. Bilsing, College Station, Texas; Mr. J. N. Knull, Harrisburg, Pennsylvania; Mr. W. S. Blatchley, Indianapolis: Mr. P. J. Darlington, Bussey Institute; Mr. K. G. Blair, British Museum; Dr. Walther Horn of Germany; and especially Dr. E. C. Van Dyke, University of California; Mr. W. S. Fisher, U. S. National Museum; Mr. L. L. Buchanan, Biological Survey, Washington, D. C.; and Mr. Ralph Hopping, Vernon, B. C., for supplying sketches and notes on species of which only the types exist.

Tribe **Clytini.**

The following characters will distinguish the members of this tribe from the rest of the Cerambycinæ. The eyes are finely granulate, partly enveloping the antennal base. The prothorax is never spinose, the elytra not sinuate (except *Tylcus*). The metepimera are produced beyond the angles of the first abdominal segment. The scutellum is rounded or broadly triangular. The front coxal cavities are open behind. The tibiæ are not carinated; the tibial spurs are long. The tarsal sole is pubescently padded. The species are variously ornamented with yellow or gray fasciæ.

It is more convenient to discuss the Clytini in two parts, and because the material available was much more complete

for the genera from *Xylotrechus* on, as arranged in Leng's Catalogue, these will be considered first, leaving the specific discussion of the *Cyllene* group until our material is more comprehensive.

The genera specifically discussed in this paper include *Xylotrechus*, *Neoclytus*, *Euryscelis*, *Clytus*, *Clytoleptus*, and *Triodoclytus*. It is felt that *Microclytus* and *Cyrtophorus*, which are included in the Clytini in Leng's catalogue, belong properly in the *Anaglypti*, because of the posteriorly constricted prothorax, narrow metepisterna, the swellings at the base of the elytra, and because the metepimera are not produced over the angles of the first abdominal segment. The character of the elytral markings is also of the latter group.

The genus *Rhopalopachys* Chevrolat, (Ann. Ent. Soc. Fr. 3rd Series, VIII, 1860, p. 457), of which there is only one species, should revert to *Neoclytus*. All of the characters mentioned by Chevrolat, such as the clubbed and spined femora, thickened antennæ, etc., are duplicated or approached in other *Neoclytus*, e. g. *N. mucronatus*, *scutellaris*, *longipes*, and *cordifer*.

Megacyllene Casey, (Mem. on Col., III, 1912, p. 348) should revert to *Cyllene*. The only real distinctions Casey makes, i. e., the heavier antennæ and slight difference in the slant of the mesosternum, are not sufficient to extablish this as a new genus. All of the characters of *antennatus* place it in *Cyllene*, i. e., the broadly rounded intercoxal process of the first abdominal segment, the perpendicular tip of the prosternal intercoxal process, the posterior excavation of the prothorax, and the conformation of the head.

Clytoleptus Casey, (Mem. on Col., 1912, p. 350) is closely related to *Chlorophorus* of Europe, but since the latter genus seems to have the eyes closer together and the front longer, *Clytoleptus* is here retained as a distinct genus. The European species of *Chlorophorus* display great variation. There are twelve species of *Chlorophorus* before me from Europe and Asia, including the type species, *C. annularis* Fabr. *Clytoleptus albofasciatus* is near the group of *Chlorophorus* containing the species *figuratus* Scop., *gracilipes* Fald., *sartor* Muller, and *lepeletieri* Pic. These have the same type of slender antennæ as *albofasciatus*, with the fourth joint considerably shorter than the third or fifth and the same narrow type of

metepisternum. The elytral markings are of the same character and the prothorax of much the same conformation.

Anthoboscus ruricola Olivier, apparently should not be included in this genus. Two specimens of *Anthoboscus tricolor* Chev., the type species of the genus *Anthoboscus* Chev., are before me. *Ruricola* is not congeneric with this species, which differs by having strong subsutural elytral carinæ, a much narrower metepisternum, and spined elytral apices. *Ruricola* and *albofasciatus* were originally placed in the genus *Clytanthus*, the main character for separating them from *Clytus* being the narrower metepisternum. The metepisternum is undoubtedly narrower in *albofasciatus* but in *ruricola* it is almost, if not quite as broad as in *Clytus*. Furthermore, I can find no satisfactory characters for separating *ruricola* from the genus *Clytus*, and, therefore, consider it as such. The form is more elongate and somewhat more convex than most of our other *Clytus* species but this is hardly sufficient to establish a separate genus. *Clytus ruricola* appears to be rather closely related to *Clytus tropicus* Panz., of Europe.

LeConte and Horn, in the Classification of the Coleoptera of North America, state that *Plagithmysus* Motschulsky, is synonymous with *Neoclytus* Thoms. Apparently this is an error. Motschulsky describes the genus (Bull. Mosc. XVIII 2, 1845, p. 369) and under it lists and describes *Plagithmysus pulverulentus* Eschsch. He distinctly states that this species is from California and since it is the only species listed, this should be the type of the genus.

Since the elytra are black striped and the prothorax with black stripes on the sides it is unlikely that this is a *Neoclytus*. In Coleopterorum Catalogus, Pars 39, fifty species, including *pulverulentus*, are listed from the Hawaiian Islands under the genus *Plagithmysus*. If the California locality is correct for *pulverulentus*, the Hawaiian species are quite likely wrongly attributed to this genus. Of course it is possible that *pulverulentus* Eschsch. cannot be identified. Evidently Motschulsky attributes *pulverulentus* to Eschscholtz simply because it appeared in the latter's collection under that name.

GENERIC KEY.

The figures in parentheses in this key refer to Plate I.

A. Intercoxal process of first abdominal segment broad, rounded or feebly angulate (1, 2).
B. Tip of prosternal intercoxal process perpendicular (5)..... **Cyllene**
BB. Tip of prosternal intercoxal process declivous or almost flat (6, 7).
C. Antennae subserrate, compressed (10), intercoxal process declivous, (6)..... **Glycobius**
CC. Antennae filiform.
D. Metepisternum narrow (27); intercoxal process almost flat (7). **Arhopalus**
DD. Metepisternum broad (26, 28), intercoxal process declivous (6).
E. Elytral margins sinuate..... **Tylcus**
EE. Elytral margins not sinuate..... **Calloides**
AA. Intercoxal process of first abdominal segment acute or subacute (3, 4).
B. Front bicarinate (8, 9), pronotum without individual transverse carinae (41). (Page 533)..... **Xylotrechus**
BB. Front not bicarinate.
C. Pronotum with individual transverse carinae (29, 30, 31).
D. Antennae eleven jointed (16, 17, 18). (Page 546)..... **Neoclytus**
DD. Antennae twelve jointed (19). (Page 560)..... **Euryscelis**
CC. Pronotum without individual transverse carinae.
D. Metepisternum narrow (23, 25).
E. Antennae tapered, basal joint robust(20). (Page 565).. **Triodoclytus**
EE. Antennae not appreciably tapered, slender (21). (Page 566), **Clytoleptus**
DD. Metepisternum broad (24). (Page 561)..... **Clytus**

Genus **Xylotrechus** Chevrolat.

Ann. Soc. Ent., Fr., VIII, 1860, p. 456. Type by original designation, *Clytus sartorii* Chevrolat. The same cited by Thomson, Monogr. on Ceram., 1860, p. 221. The same cited by Casey, Mem. on Col. III, 1912, p. 349.

The members of this genus have, generally, a robust form, the front of the head declivous, with bicarination thereon. The antennæ are filiform and in length usually less than half that of the body length. The elytra are generally appreciably tapered, the apices truncate or rounded. The femora are not distinctly spined.

XYLOTRECHUS, SPECIFIC KEY.

A. Frontal carination V- or Y-shaped.
B. Elytral apices definitely spined.
C. Spines acute, form elongate. (Page 534)..... 1. **sagittatus**
CC. Spines short, more obtuse, form shorter, more robust. (Page 535), 2. **nauticus**
BB. Elytral apices not spined.
C. Apices truncate.
D. First elytral marking, at basal sixth, in the form of a short dash or dot.
E. Second or mid-elytral fascia undulatory.
F. Pronotum with a clear-cut fascia at apex. (Page 536), 3. **undulatus**
FF. Pronotum without a distinct fascia at apex.
G. Elytral fascia at apical third directed up the suture. (Page 540)..... 7. **lengi**
GG. Elytral fascia at apical third directed down the suture.

H. Pronotum sparsely, uniformly pubescent. (Page 539), **5. bowditchi**
HH. Pronotum densely pubescent.
J. Pubescence not uniform, patchy. (Page 538)...**4. fuscus**
JJ. Pubescence fairly uniform. (Page 539).....**6. abietis**
EE. Second or mid-elytral fascia not undulatory.
F. Mid-elytral fascia strongly posteriorly arcuate.
G. Elytral fasciae narrow. (Page 540).....**8. schaefferi**
GG. Elytral fasciae broad.
H. Pronotal fasciae broad, clear cut. (Page 541)..**10. insignis** ♀
HH. Pronotal fasciae narrow or absent; mid-elytral fascia generally absent; elytra sometimes covered with dense pubescence. (Page 541).....**insignis** ♂
FF. Mid-elytral fascia transverse, entire or divided into two parts. (Page 540).....**9. mormonus**
DD. Elytral marking at basal sixth an undulatory or sinuous band.
E. Elytral fascia at apical fourth as broad or broader than the interval behind it. (Page 543).....**13. colonus**
EE. Elytral fascia at apical fourth narrower than the interval behind.
F. Antennae over half the body length, tapered; metepisternal spot conspicuous. (Page 544).....**14. quercus**
FF. Antennae less than half the body length, filiform; metepisternal spot very faint. (Page 544).....**15. annosus**
CC. Elytral apices separately rounded.
D. Elytral markings in the form of ten yellow dots, sometimes reduced to only two. (Page 542).....**12. obliteratus**
DD. Elytral markings in the form of gray bands. (Page 542), **11. nunenmacheri**
AA. Frontal carination lozenge-shaped, closed at each end.
B. Form narrow, elongate, elytral fasciae very narrow, gray, obscure.
C. Dashes in front pronotal angles extending ventrad. (Page 544), **16. aceris**
CC. Dots in front pronotal angles not extending ventrad. (Page 545), **17. quadrimaculatus**
BB. Form robust, elytral fasciae conspicuously clear cut.
C. Mid-elytral fascia deeply posteriorly arcuate. (Page 545), **18. convergens**
CC. Mid-elytral fascia obtusely angled, oblique. (Page 545)....**19. nitidus**

1. **Xylotrechus sagittatus** Germar.

(Plate II, Fig. 2.)

X. sagittatus Germar, Magazin der Entomologie, Halle, IV, 1821, p. 171.
cylindrus Casey, Mem. on Col., III, 1912, p. 364.
salebrosus Casey, Mem. on Col., III, 1912, p. 364.
A. *pubescens* Haldeman, Trans. Am. Phil. Soc. (2) X, 1847, p. 40. (Var.).

Ground color red-brown to almost black. Pronotum carinulate, without fasciæ, with gray pubescence toward the sides which are more suddenly rounded posteriorly. Elytral margins slightly convergent, apices obliquely truncate; elytral markings: a subhumeral spot; gray pubescent lines along suture and margin with short offshoots at basal and apical thirds. Ventral surface and legs uniformly covered with fine gray pubescence. Eight specimens before me from Ontario, Quebec, New Jersey, and Alabama. Length, 12–21 mm.; breadth, 3.75–6 mm.

Hosts: *Pinus, Picea, Abies.*[1]

[1]Craighead, N. A. Cerambycid Larvae, 1923, p. 57.

There is one specimen before me from Manitoba which is apparently the variety *pubescens*. It agrees with the description except that the elytral apices cannot be described as acutely spined, as they are but feebly so at the outer angle of truncature. The sutural and marginal offsets almost coalesce and the posterior margins of the ventral abdominal segments are pale pubescent which is not the case with typical *sagittatus*.

There are no characters of sufficient value to establish Casey's *cylindrus* and *salebrosus* as distinct species. The differences are based upon characters which display great variation within this species, such as vestiture, color, and slight differences in the form of prothorax. Mr. L. L. Buchanan says of these: "I can only say that the differences mentioned by Casey, whether specific or merely individual, are shown by his specimens. Certain of these differences, as the more rhomboid form of body in *sagittatus*, are very slight, and would probably break down in a larger series. *Cylindrus* has the body more nearly parallel and the pubescence more conspicuous than *sagittatus*, but the ground color of the two is the same (brown). *Salebrosus* is nearly black with the elytral pubescent bands more sharply defined and the sides of the prothorax less convergent apically."

2. **Xylotrechus nauticus** Mannerheim.

(Plate II, Fig. 7.)

X. nauticus Mannerheim, Bull. Moscou XVI, 1843, p. 305.
gramineus Haldeman, Trans. Am. Phil. Soc. (2) x, 1847, p. 40.

Ground color dark brown to black. Pronotum carinulate, sparsely and patchily gray pubescent. Elytral apices truncate; elytral markings in the form of three wavy, narrow fasciæ, placed at apical and basal fourths, and at middle, these often indistinct. Ventral surface uniform dark brown, with sparse gray pubescence. Femora rather strongly clavate. Thirty-five specimens before me from various parts of California. Length, 9–16 mm.; breadth, 3–5.5 mm.

Hosts: *Quercus*, *Eucalyptus*.[2] Essig states that it "attacks the English walnut, Coast live oak, black oak, and, according to Van Dyke, peach."[3]

X. gramineus Hald., apparently does not differ from *nauticus*. Mr. Ralph Hopping made the following observation while on a visit to the LeConte collection: "There are four specimens

[2]Craighead, N. A. Cerambycid Larvae, 1923, p. 57.
[3]Essig., Inj. and Benef. Ins. of Calif. 1915, p. 254.

labelled var. *gramineus*. All of these specimens are placed with *X. nauticus* which they evidently are." Leng states: "*X. gramineus* does not differ in any way from *nauticus*."[4]

The *undulatus* group contains seven closely allied species, namely, *undulatus, lengi, fuscus, abietis, bowditchi, mormonus*, and I think also *schaefferi*, although I have not seen the last. The observation which Casey made with regard to the difference in head punctation of the two sexes of *undulatus*[5] applies to the first six of these species and probably to the last one. The head of the female is rather coarsely punctate all over, but the head of the male has two large, well defined, finely granulate, pear-shaped areas on the vertex, extending up to the margin of the pronotum and sometimes covered by it according to the position of the head. This sexual difference is apparent in a few other species of *Xylotrechus*, such as *insignis*, but to a lesser degree, the areas being smaller and less sharply defined.

3. **Xylotrechus undulatus** Say.

(Plate II, Fig. 3; Plate V, Fig. 12.)

X. undulatus Say, Long's Second Expedition II, 1824, p. 291.
sayi Castelnau, Monogr. du genre Clytus, Paris, 1835, p. 55.
interruptus Castelnau, Monogr. du genre Clytus, Paris, 1835, p. 57.
lunulatus Kirby, Ins. in Rich. Faun. Bor. Am. IV, London, 1837, p. 175.
undatus Kirby, Ins. in Rich. Faun. Bor. Am., IV, London, 1837, p. 175.
integer Haldeman, Trans. Am. Phil. Soc. (2), X, 1847, p. 41.
gemellus Casey, Ann. N. Y. Ac. Sc., VII, 1893, p. 590.
longitarsis, *montanicus*, *inflaticollis*, *columbianus*, *albonotatus* } Casey, Mem. on the Col. III, 1912, pp. 360–362.

This is one of the most variable species of *Xylotrechus* the synonymy of which was confused until LeConte and Horn examined the Kirby types and other types in the European collections. The synonyms thus established appear in a condensed compilation by Horn in *The Canadian Entomologist*, VIII, 1876, p. 169. In view of this past confusion it is well to quote Say's description of *undulatus:*

"Body dark brown, head darker than the elytra, antennæ, dark ferruginous; front below the antennæ bilineate with pale yellow; thorax darker than the elytra, rough with minute spines and hairs, anterior and inferior margins yellow, interrupted above, basal margin with a transverse yellow spot each side; elytra with a transverse spot on each

[4]Leng, Entomologica Americana, III, 1887, p. 4.
[5]Casey, Mem. on Col., III, 1912, p. 360.

near the base, an undulated narrow band across the middle, rising along the suture nearly to the scutel, an undulated transverse band behind the middle, and a terminal band; postpectus with incisures margined with yellow."

The form most commonly taken in the west, from California to Alaska, agrees closely with this description except that the undulated bands are often interrupted. The fasciation of the males is generally white, of the females, yellow. There are fifty-eight specimens before me from Alaska, British Columbia, California, Oregon, Alberta, Ontario, New Brunswick, Michigan, and Colorado. Length, 9.5–16 mm.; breadth, 2.75–5.5 mm. Type locality N. W. Terr.

Hosts: *Pseudotsuga, Tsuga, Pinus, Picea.*[6]

Of *X. gemellus* Csy., Leng and Hamilton[7] say: "Described from two examples and represented as differing from *undulatus* chiefly by the coarser sculpture of the pronotum, suffused pale pubescence extending across the base of the elytra, and less prominent frontal carinæ; the transverse bands different in form, being wider and posteriorly arcuate where, in *undulatus*, they are anteriorly angulate. The individuals of *undulatus* vary greatly in coarseness or fineness of sculpture, in pubescence, and in distinctness of elytral bands, and none of the differences mentioned by Mr. Casey seem of any value, unless it be the last mentioned."

X. undatus Kirby, and *X. lunulatus* Kby. were determined as synonyms of *undulatus* Say by LeConte and Horn after examination of the types.[8] Haldeman says: "*X. undatus* Kby. = *X. sayi* Cast."[9] Evidently *X. sayi* Cast. is also *undulatus* Say.

X. integer Hald. is represented as a variety of *undulatus* Say, having the "undulated line upon the elytra obsolete."[10] In the *undulatus* series before me, there is every gradation, from the entire, undulated mid-fascia to none at all.

X. interruptus Cast. is the variation of *undulatus* Say, having longitudinal rays connecting the fasciæ. Leng says:[11] "the form with the bands greatly obscured by a sprinkling of white hairs." Casey, however, states that[12] this is "the rayed form with slightly shorter elytra."

---

[6]Craighead, N. A. Ceram. Larvae, 1923, p. 58.
[7]Leng and Hamilton, Ent. Am. II, p. 172.
[8]Horn, Can. Ent., VIII, 1876, p. 169.
[9]Haldeman, Trans. Am. Phil. Soc., X, N. S. 1847, p. 372.
[10]Haldeman, Trans. Am. Phil. Soc., X, N. S. 1847, p. 41.
[11]Leng, Ent. Am. III, 1887, p. 201.
[12]Casey, Mem. on Col., III, 1912, p. 362.

X. longitarsis Csy., and *montanicus* Csy., are variations of *undulatus*. Casey states:[13] "*Longitarsis* and *montanicus* may be regarded as subspecies of *undulatus*." *Columbianus*, *inflaticollis*, and *albonotatus* are variations of *undulatus*. Mr. L. L. Buchanan says of these species:

"*X. columbianus* (1 ex. in Casey's coll.); broader than *undulatus*, ante-apical band much broader; no sharp external angles at apical truncature of elytra. This external sharp angle is well defined in some specimens of *undulatus*, feeble in others.

"*X. inflaticollis* (1 ex. in Casey's coll.). The prothorax is wider compared to the elytra than in *undulatus*, and the ante-apical fascia is entire; otherwise it looks like *undulatus*.

"*X. albonotatus* (1 ex. in Casey's coll.). The white bands and spots contrast strongly with the black ground color; the bands are broader in general and especially that one across the apex of the pronotum, than in *undulatus*, though there is considerable variation of this character among the specimens of the latter series."

4. **Xylotrechus fuscus** Kirby.

(Plate II, Fig. 4.)

X. fuscus Kirby, Ins. in Rich. Faun. Bor. Am. IV, London, 1837, p. 176.

This is a distinct species, constant in characters. Dr. Van Dyke says of it:[14] "A species which has been proven by Mr. C. A. Frost to feed on the true firs, *Abies*, and as stated by Colonel Casey, is quite distinct from *undulatus*." It is also said to bore in hemlock.[15]

The ground color is dark brown to black. Head sometimes completely covered with gray or yellow pubescence. Elytral markings: a short and narrow subhumeral wavy line; a narrow, wavy fascia at middle, extending up the suture almost to the scutellum and a wavy narrow fascia at apical third. The fasciæ are sometimes joined by narrow longitudinal rays. In some specimens the markings on the elytra are almost obsolete but the patchy pubescence on the pronotum is distinctive. Ventral surface with condensed patches of gray pubescence posteriorly on the metepisterna, metasternum, and abdominal segments. Twenty-two specimens examined from New Brunswick, Maine, New York, and Pennsylvania. Length, 10–15 mm.; breadth, 3–5 mm.

[13]Casey, Mem. on Col., XI, 1924, p. 270.
[14]Van Dyke, Bull. Brook. Ent. Soc., XX, p. 42.
[15]Craighead, N. A. Ceram. Larvae, 1923, p. 57.

5. **Xylotrechus bowditchi** G. Hopping.

X. bowditchi G. Hopping, Can. Ent., LX, 1928, p. 246.

The head is almost black, prothorax lighter, and elytra still paler brown. The pronotum has rough cariniform sculpturing and is sparsely and uniformly covered with short, semi-erect, gray pubescence. The fasciation is arranged as in *undulatus* but narrower and much less strongly indicated. The ventral surface is sparsely and evenly covered with gray pubescence without any condensed spots or bands. It was described from a single male from Mr. C. A. Frost's collection. Length, 3 mm.; breadth, 3.75 mm. Type locality, Florissant, Colorado.

Host: spruce.

6. **Xylotrechus abietis** Van Dyke.

(Plate II, Figs. 10, 11.)

X. abietis Van Dyke, Pan. Pac. Ent., V, 3, 1929, p. 136.
cinereus Van Dyke, Bull. Brook. Ent. Soc., XV, 2, p. 41.

This is a valid species, distinct from *undulatus*. The name *cinereus* was preoccupied by Castelnau and Gory, Monogr. du genre Clytus, 1835, p. 68. Dr. Van Dyke observes: "This species not only differs from *undulatus* by its colour and distinctive colour pattern, but by having a different food tree. It always breeds in the true firs, *Abies*, as both Mr. Hopping and I have many times observed, whereas *undulatus* lives in either the true spruces, *Picea*, or their closer relatives like *Pseudotsuga*."[16]

The ground color is black. Head rather densely white or gray pubescent. Scutellum always clothed. Elytral markings; a subhumeral gray dash; a fascia beginning a little behind the scutellum, extending backward, keeping strictly to the suture as far as the middle, where it curves outward, undulating to the margin; a fascia at apical third also undulated, generally interrupted; and an apical gray patch. The suture is generally margined with pale pubescence clear to the apices. The entire body is often covered with cinereus pubescence, through which the elytral design shows dimly. Legs covered with cinereus pubescence. Twenty-three specimens before me, one a paratype male, all from the Sierra Nevada Mountains of California. (Tulare and Fresno Co's.). Length, 11–20 mm.; breadth, 3.5–6.5 mm. Type locality, male, Fallen Leaf Lake, Tahoe, California; female, Atwood's Mill, Tulare Co., California.

---

[16]Van Dyke, Bull. Brook. Ent. Soc., XV, 2, p. 42.

7. **Xylotrechus lengi** Schaeffer.

(Plate IV, Fig. 2.)

X. lengi Schaeffer, Bull. Brook. Inst., I, 1908, p. 340.

A small species, brown to black; elytral markings similar to ***undulatus*** but indistinct and differing as noted in the key. Elytral apices with faint apical spot. Ventral surface without any condensed patches of pubescence, but with body and legs uniformly and sparsely covered with fine gray pubescence. A homotype is before me from Lassen Co., California, compared by Dr. Van Dyke, and another specimen from near Princeton, B. C., collected by Mr. G. Stace Smith. Length, 9–11 mm.; breadth, 3–3.5 mm. Type locality, Dilley, Oregon.

Host: *Pseudotsuga taxifolia.*

8. **Xylotrechus schaefferi** Schott.

(Plate V, Fig. 2.)

X. schaefferi Schott, Journ. N. Y. Ent. Soc., Vol. XXXIII, 4, 1925, p. 224.

I have not seen this species. Apparently only the type is known. It seems to belong to the ***undulatus*** group in spite of the fact that the mid-elytral fascia is not undulatory. The original description is as follows:

"Body sub-parallel; head piceous, finely rugose, clothed with inconspicuous, grayish hairs; frontal carinæ well defined, V-shaped; antennæ dark brown; thorax broad as long, narrower than the elytra, parallel to slightly below the middle, thence constricted to base; in profile vaguely depressed and abruptly sloping near posterior margin, piceous, granulose, medially coarser, hirsute patches yellow; elytra moderately rugose, scantily clothed with prostrate pale hairs; brownish black; a short band of yellow hairs near base, a conspicuous line of yellow hairs from suture near the basal mark, curving in a deep arc across the center of elytra toward, but not quite reaching, the lateral margin; an apical transverse line of yellow from suture to near the lateral margin and thence recurved upward; apices of elytra obliquely truncate; underside piceous with grayish hairs forming bands on hind margins of segments; legs reddish brown, femoral turgidity darker. Length, 11.0 mm.; with, 3.5 mm. Type locality, Lakehurst, New Jersey."

9. **Xylotrechus mormonus** LeConte.

(Plate I, Fig. 12; Plate V, Fig. 1.)

X. mormonus LeConte, Proc. Ac. N. S. Phila., 1861, p. 357.

This species and ***obliteratus*** have long been confused by some coleopterists. It is hard to understand how this confusion started, in view of the fact that ***mormonus*** belongs to the ***insignis*** group. This will be discussed more fully under ***obliteratus***.

The form of *mormonus* is like *undulatus*. Front of head and genæ gray pubescent; antennæ shorter than half the body length. Pronotum with pubescence somewhat more condensed at the angles. Elytra sparsely covered with coarse gray pubescence, apices obliquely sinuate-truncate, the markings in the form of a narrow subhumeral dash; a transverse fascia a little before the middle, dilated at each end, not attaining suture or margin, sometimes broken into two maculæ; a slightly undulating fascia at apical third, sometimes interrupted; apical patch very faint or absent. Ventral surface and legs with sparse gray pubescence, slightly more condensed posteriorly on the metepisterna, metasternum, and abdominal segments. Eleven specimens examined from Colorado and New Mexico. Length, 12–17 mm.; breadth, 3.75–5.5 mm. Type locality, Utah.

The *insignis* group has also caused some confusion in the past. To this group belongs *X. insignis*, *nunenmacheri*, and *obliteratus*.

10. **Xylotrechus insignis** LeConte.

(Plate II, Figs. 13, 14.)

X. insignis LeConte, Smith. Misc. Coll., XI, 264, 1873, p. 199.
incongruens Casey, Mem. on Col., III, 1912, p. 366.
diruptus Casey, Mem. on Col., III, 1912, p. 367.

The female of this species is the most brilliantly ornamented of our *Xylotrechus*. The ground color is black anteriorly, gradually becoming brown posteriorly. Front bilineate with yellow pubescence, antennæ brown. Pronotum broadly margined with yellow apically and basally. Elytra subparallel, apices feebly truncate; markings: a yellow patch bordering the scutellum posteriorly; a broad subhumeral dash, oblique, a fascia beginning a little behind the scutellum, extending backward and outward in a deep arcuation to the margin; a fascia at apical third, slightly arcuate oblique, and a broad apical patch. Ventral surface with yellow pubescent patches posteriorly on the mesepisterna, metepisterna, and practically covering the abdominal segments. Legs light brown. Five females before me from Fresno, Alameda, and Nevada counties, California. Length, 18 mm.; breadth, 5 mm. Type locality, California.

The male differs markedly from the female. The ground color is cinnamon-brown. The pronotum has the basal and marginal fasciæ reduced to a hair line or absent. The mid-elytral fascia is generally missing, and many specimens have the elytra and ventral surface densely yellow pubescent, through which the elytral design shows dimly. Only two specimens before me have the mid-elytral fascia present, narrow.

This is not *obliteratus* Lec. Mr. J. J. Rivers was the first to rear the two sexes of *insignis*, from willow. There are thirty-one males before me from Sonoma, Mendocino, and San Luis

Obispo Counties, California, and from Catalina Island. Length, 13–17 mm., breadth, 4–5.5 mm.

X. incongruens Csy. and *X. diruptus* Csy. are the same as *insignis*. Casey states:[17] "*Diruptus* Csy., should be united with *insignis*. The differences appear too slight to warrant even the status of a sub-species." He could have included *incongruens* in the same statement. Dr. Van Dyke says:[18] "Colonel Casey's *incongruens* is the northern suffused form of *insignis*, and his *X. diruptus*, the female of one of the southern phases."

11. **Xylotrechus nunenmacheri** Van Dyke.

(Plate II, Fig. 15.)

X. nunenmacheri Van Dyke, Bull. Brook. Ent. Soc., XV, 2, 1920, p. 43.
uniformis Casey, Mem. on Col., XI, 1924, p. 270.

Only the male of this species is known. The form is like *insignis* but the ground color is dark brown. Pronotum without fascia. Elytral margins almost parallel, apices separately rounded; markings placed as in *insignis*, but gray instead of yellow, and somewhat obscured by a sparse vestiture of gray hairs. Ventral surface without condensed pubescent areas, sparsely covered with gray pubescence.

Mr. Nunenmacher is apparently the only one who has taken this species. Dr. Van Dyke prefers to consider it as a race of *insignis*. It seems to warrant specific rank, but its true status cannot be determined until the female is found. Some of the specimens in the Nunenmacher series are without elytral fasciæ. There is one specimen before me. Length, 17 mm., breadth, 5 mm. Type locality, Josephine County, Oregon.

X. uniformis Csy., was described from a specimen from the Nunenmacher series. It is the same as *nunenmacheri*.

12. **Xylotrechus obliteratus** LeConte.

(Plate II, Fig. 16.)

X. obliteratus LeConte, Smith. Misc. Coll., XI, 264, 1837, p. 199.

This is not the male of *insignis*. It has appeared in some collections under the name *mormonus*, and has been under this name in The Hopping collection, so labelled by Dr. Van Dyke, who has subsequently straightened out the confusion by examining the type.

---

[17]Casey, Mem. on Col., IV, 1913, p. 387.
[18]Van Dyke, Bull. Brook. Ent. Soc., XV, p. 43.

The ground color is cinnamon-brown to black. Pronotum without markings, sometimes sparsely covered with gray pubescence. Elytral margins parallel; markings: a faint subhumeral dash; two spots in a transverse line (on each elytron) at middle, and two in a transverse line at apical third, making ten dots or small dashes in all. Sometimes these are reduced to only two dots near the middle. Elytra sparsely covered with gray pubescence. In the type the dashes are joined, the mid-fascia extending up the suture as in ***insignis*** but much narrower and obscure. I have seen one such specimen but this does not seem to be true of the majority of specimens. The ventral surface is without condensed pubescent patches but is sparsely and uniformly gray pubescent. Two males and three females from British Columbia are before me, and another female sent by Dr. Van Dyke. The two males are cinnamon-brown, the females black and considerably larger than the males. Length, 12–16 mm.; breadth, 3.75–5 mm. Type locality, Colorado.

Host: *Populus tremuloides.*

In the Leng catalogue, under *X. obliteratus* Lec., the name ***brevipennis*** Lec. has been placed as a synonym, with a question mark. The type of this has been examined by Mr. Ralph Hopping and I have since received a specimen of it. It is a true *Cyllene* and has been so placed in the Supplement to Leng's catalogue, 1920–1924, by Leng and Mutchler.

13. **Xylotrechus colonus** Fabricius.

(Plate II, Fig. 1.)

X. colonus Fabricius, Systema Entomologiae, Flensburg and Lipsiae, 1775, p. 191.
villicus Olivier, Entomologie, IV, Paris, 1795, p. 64.
campestris Olivier, Entomologie, IV, Paris, 1795, p. 65.
terminans Fabricius, Supplementum Entomologia Systematica, Hafniae, 1798, p. 151.
coloreus Fabricius, Systema Eleutheratorum, Kiliae, 1801, p. 345.
upsilon Stephens, Illust. Brit. Ent. Mand., London, 1831, p. 244.
agrestis LeConte, Journ. Ac. N. S. Phila. 2, II, 1850, p. 28.

Ground color brown to black. Antennæ sometimes half the length of the body, and appreciably tapered. Pronotum with a tendency toward carinulation, sometimes with faint yellow pubescent spots in the pronotal angles, and two on the disc. Elytral margins subparallel, apices truncate. Markings: a sinuate subhumeral yellow line from the scutellum backward and outward to the margin; an undulatory broad gray band at basal third; a broad, transverse, gray band at apical third, broader at suture than the interval behind it; and an apical gray patch. Ventral surface with condensed yellow pubescence posteriorly on the metepisterna, mesepisterna, and sometimes on the posterior margins of the abdominal segments. Femora dark brown, tibiæ and tarsi lighter. Twenty-five specimens before me from Kansas, Massachusetts, Pennsylvania, New Jersey, Michigan, Iowa, New York. Length, 10–15 mm.; breadth, 3–4.25 mm.

It has been reared from *Tsuga canadensis*, by Champlain and Knull,[19] and is reported to occur in chestnut. Blatchley says it is found in oak, beech, and maple.[20] Craighead says it bores in almost all of the eastern hardwood trees.[21]

The variety *agrestis* Lec. differs by having the mid-elytral fascia interrupted. In a review of Olivier's species, Horn says: "*Campestris* equals *Xylotrechus colonus* and *villicus* the same."[22]

14. **Xylotrechus quercus** Schaeffer.

(Plate IV, Fig. 1.)

X. quercus Schaeffer, Bull. Brook. Inst. I, 1905, p. 163.

Pronotal sculpture extremely rough, bordering on carinulate. Elytral apices truncate, the fasciæ narrow, gray, the first sinuate as in *colonus*, the mid-fascia with two arcuations, the outer one farther forward than the sutural one; a fascia at apical third undulatory; and an apical patch. A specimen is before me, sent by Mr. Schaeffer. Length, 11 mm.; breadth, 3.5 mm. Type locality, Arizona.

15. **Xylotrechus annosus** Say.

(Plate II, Fig. 6.)

X. annosus Say. Journ. Ac. N. S. Phila., V, 1827, p. 277.

Pronotum without fascia, patchily, rather sparsely covered with gray pubescence. Elytra sparsely and uniformly covered with gray pubescence, the margins subparallel, apices feebly truncate; markings in the form of three narrow wavy fasciæ. Ventral surface and legs uniformly and sparsely gray pubescent. In the west it bores in *Populus trichocarpa* and probably other *Populus* species. Mr. D. W. Coquillet reared it from *Salix* in 1880.[23] Twenty-nine specimens before me from Alberta, British Columbia, and California. Length, 10.5–15 mm.; breadth, 3–4.5 mm.

16. **Xylotrechus aceris** Fisher.

(Plate II, Fig. 9.)

X. aceris Fisher, Proc. Ent. Soc. Wash., XVIII, 1916, p. 215.

Form slender. Pronotum brown or black with a spot or dash in each angle, those in the front angles extending ventrad. Elytra ochraceous or brown, the apices narrowly truncate; markings: a hair line white fascia, beginning near the scutellum, passing backward and outward in a shallow arcuation, acutely angled near the margin, re-

[19]Champlain and Knull, Ent. News, XXXVI, 1925, p. 139.
[20]Blatchley, Col. of Ind., 1910, p. 1037.
[21]Craighead, N. A. Ceram. Larvae, 1923, p. 57.
[22]Horn, Am. Ent. Soc. of Phila., 1886.
[23]Coquillet, Can. Ent., XV, 1880, p. 31.

turning forward half way to the humerus; an oblique hair line fascia at apical third. The markings are sometimes very faint. Ventral surface with condensed patches of gray vestiture posteriorly on the mesepisterna, metepisterna, metasternum, and first three abdominal segments. Legs brown or black. Five specimens before me from Pennsylvania, New York, and Maine. Length, 10–14 mm.; breadth, 2.5–3.75 mm.

17. **Xylotrechus quadrimaculatus** Haldeman.

(Plate II, Fig. 5.)

X. quadrimaculatus Haldeman, Trans. Am. Phil. Soc., 2, X, 1847, p. 41.

Form slender. Pronotum brown or black with a spot in each angle, the anterior ones more or less triangular, not extending ventrad. Elytra ochraceous or brown, somewhat more tapering than in *aceris*, the markings similar. Ventral surface and legs brown or black with condensed patches of pubescence posteriorly on the metepisterna, metasternum, and first two abdominal segments. Ten specimens before me from Ontario, Manitoba, Quebec, Maine, and Pennsylvania. Length, 7.5–14 mm.; breadth, 2–3.5 mm. Type locality, Pennsylvania.

According to Champlain and Knull, "*quadrimaculatus* girdles the limbs of beech, alder, and birch, while *aceris* infests the heart wood of red maple, *Acer rubrum*, silver maple, *Acer sacharinum*, and sugar maple, *Acer sacharum*."[24]

18. **Xylotrechus convergens** LeConte.

(Plate II, Fig. 8.)

X. convergens LeConte, Smith. Misc. Coll., 264, II, 1873, p. 198.

Ground color dark brown to black. Front bilineate with yellow pubescence. Pronotum margined with yellow, sometimes interrupted anteriorly; two yellow convergent dashes on the disc, near posterior margin. Elytral suture margined with pale pubescence; a subhumeral oblique yellow dash; a narrow yellow fascia at middle, deeply, posteriorly arcuate; a narrow, oblique, fascia at apical third; apices pale pubescent. Ventral surface with condensed pubescent patches posteriorly on the mesepisterna, metepisterna, and narrowly on the abdominal segments. Femora extremely clubbed, almost black, tibiæ and tarsi lighter. Length, 11–13 mm.; breadth, 4 mm. Type locality, Ohio.

Host: *Crataegus*.[25]

19. **Xylotrechus nitidus** Horn.

(Plate IV, Fig. 14.)

X. nitidus Horn, Proc. Ac. N. S. Phila., 1860, p. 572.

Form more slender than *convergens*, ground color black. Pronotum with anterior and posterior margins yellow pubescent, interrupted at

[24]Champ. and Knull, Ent. News, XXXVI, 1925, p. 139.
[25]Craighead, N. A. Ceram. Larvae, 1923, p. 56.

middle; a transverse row of four yellow dashes just behind the middle. Elytral margins convergent, apices truncate; markings yellow, narrow but clear cut; a subhumeral transverse dash; a straight fascia oblique backward from the suture at basal third; a mid-fascia oblique backward from suture, obtusely angled at middle; a transverse, slightly arcuate fascia at apical third, and apices margines with yellow. One specimen is before me, taken at Chambersburg, Pennsylvania. Length, 11 mm.; breadth, 3.5 mm. Type locality, Texas.

Mr. Charles Liebeck has called my attention to the fact that all specimens collected since the type, have been taken in or near the New England States. He suggests that the Texas locality may be an error, which appears probable.

Genus **Neoclytus** Thomson.

Musee Scientifique, 1860, p. 67.

Rhopalomerus Chevrolat, Ann. Soc. Ent. Fr., VIII, 1860, p. 457.
Rhopalopachys Chevrolat, Ann. Soc. Ent. Fr., VIII, 1860, p. 457.
Plagithmysus Lec. and Horn, Classif. Col. of N. A., 1883, p. 304.
Type by original designation, *N. erythrocephalus* Fabricius.

Thomson states that the name *Rhopalomerus* Chev. was preoccupied by Wiedemann (Analecta Ent., Dipteres, Muscidæ, 1824). Casey cites *Clytus luscus* Fabr. as the type of the genus, but apparently this is an error.[26]

The form of *Neoclytus* is more slender than in the preceding genus, the front of the head more perpendicular and without the bicarination. The antennæ are generally less than half the body length. The sides of the prothorax are not as fully rounded as in most of the *Xylotrechus*, and the pronotum has individual transverse carinæ. The elytra are ornamented with yellow or white bands, are generally truncate at tips and sometimes spined. The femora are sometimes acutely spined at the tips.

NEOCLYTUS, SPECIFIC KEY.

A. Elytral apices acutely spined.
  B. Prothorax with two tubercles on each side.
    C. Middle and hind pair of legs notably long. (Page 548).....1. **longipes**
    CC. Only the hind legs notably long. (Page 548).....2. **cordifer**
  BB. Prothorax without lateral tubercles.
    C. Pronotum without fasciae. (Page 550).....5. **irroratus**
    CC. Pronotum fasciated.
      D. Fasciae two, apical and basal. (Page 549).....4. **mucronatus**
      DD. Fasciae three, apical, middle, and basal. (Page 549)....3. **scutellaris**

[26]Casey, Mem. on Col., III, 1912, p. 350.

AA. Elytral apices not acutely spined.
B. Elytral apices definitely truncate or with the inner truncature angles so rounded as to make the apices appear separately, obtusely angulate.
C. Antennae appreciably thickened distally.
D. Scutellum naked.
E. Pronotum without fasciae.
F. Elytral fasciae only two. (Page 559).....24. **jouteli**
FF. Elytral fasciae more than two.
G. Prothorax as long as broad, elytral fasciae straight. (Page 550).....6. **acuminatus**
GG. Prothorax considerably longer than broad; elytral fasciae angled or curved. (Page 558).....23. **kirbyi**
EE. Pronotum with three transverse fasciae. (Page 551)..7. **torquatus**
DD. Scutellum clothed.
E. Mid-elytral fascia suddenly angled near the suture.
F. Elytral fascia at basal third oblique forward from the suture, not nearly attaining the margin. (Page 551).....9. **abbreviatus**
FF. Elytral fascia at basal third oblique backward from suture.
G. Elytral fasciae at apical and basal fourths increasing in width as they approach the suture.
H. Middle and hind fasciae steeply oblique; elytra narrowed apically. (Page 552).....11. **vanduzeei**
HH. Middle and hind fasciae moderately oblique; elytra less strongly tapered. (Page 551).....10. **approximatus**
GG. Elytral fasciae at apical and basal fourth not appreciably wider as they approach the suture. (Page 553)....12. **tenuiscriptus**
EE. Mid-elytral fascia not angled near suture.
F. Sub-basal fascia expanded forward, occupying, or nearly occupying the entire basal fourth. (Page 553).....14. **basillaris**
FF. Sub-basal fascia well separated from basal margin.
G. Sub-basal fascia obtusely angled near margin. (Page 556), 18. **magnus**
GG. Sub-basal fascia not angled.
H. Mid-elytral fascia oblique.
J. Pronotum covered with ash-gray pubescence. (Page 551), 8. **peninsularis**
JJ. Pronotum not covered with ash gray pubescence. (Page 553).....13. **interruptus**
HH. Mid-elytral fascia transverse, straight.
J. Fasciae white. (Page 555).....17. **angelicus**
JJ. Fasciae yellow.
K. First fascia acutely prolonged anteriorly near the margins. (Page 555).....16. **provoanus**
KK. First fascia not prolonged as above. (Page 554), 15. **balteatus**
CC. Antennae not appreciably thickened distally.
D. Scutellum naked.
E. Each elytron with a fascia extending forward from the outer end of the mid-fascia. (Page 558).....22. **ascendens**
EE. Elytra without such fasciae.
F. Mid-elytral fascia obtusely angled at suture. (Page 557), 20. **muricatulus**
FF. Mid-elytral fascia straight. (Page 557).....21. **infans**
DD. Scutellum clothed.
E. Elytral fasciae entire, arcuate; pronotum with interrupted mid-fascia and sometimes a marginal fascia. (Page 556)..19. **modestus**
EE. Elytral fasciae generally reduced to oblique sutural dashes; pronotum without fascia. (Page 556).....**modestus**
BB. Elytral margin strongly and evenly rounded toward the suture at apex, meeting the sutural line sub-acutely.
C. Mid-elytral fascia connected with fascia at apical fifth along the suture. (Page 559).....25. **conjunctus**
CC. Mid-elytral fascia not connected as above. (Page 560).....26. **caprea**

1. **Neoclytus longipes** Drury.

(Plate V, Figs. 3, 4.)

N. longipes Drury, Illust. of Nat. Hist., etc., London, 1770, p. 84.
druryi Fabricius, Systema Entomologiae, Flensburg and Lipsiae, 1775, p. 181.
lunulatus Goeze, Entomologische Beytrage, Z-D. Ritter, Linne, 12 ed. I, Leipzig, 1777, p. 477.
angulatus Fabricius, Entomologia Systematica, Hafniae, I, 1792, p. 335.
rhombifer Olivier, Entomologie IV, Paris, 70, 1795, p. 46.
hopei Castelnau, Monogr. du genre Clytus, Paris, 1835, p. 18.

Ground color cinnamon brown. Prothorax sparsely pubescent, more condensed apically and basally; pronotum evenly and densely punctate; markings: a fascia, beginning at the suture near the base, transverse almost to margin, thence oblique backward to the suture again at basal third; a small dot at middle near the margin; a transverse fascia at apical third, wide at suture, gradually narrowing toward the margin; a faint apical patch. There is a pair before me from the West Indies, sent by Mr. K. G. Blair. The markings on the male are gray and inconspicuous, on the female yellow. Length, 16 mm.; breadth, 4.5 mm. Habitat West Indies and Florida.

Mr. Blair has given me the following note on this species: "The two sexes are rather markedly different, Drury's figure applying to the male. The female was described as *Callidium angulatum* by Fabricius (Type in British Museum). Naturally the synonymy is a little involved, Fabricius in another place describing the male as *druryi* (the page reference given by Aurivilius apparently is erroneous; it should be 181 instead of 408). Castelnau and Gory also described the two sexes, the male as *hopei*, the female as *rhombifer*, though Olivier correctly figured both sexes as *rhombifer*."

2. **Neoclytus cordifer** Klug.

(Plate III, Fig. 13.)

N. cordifer Klug, Preisverzeichniss vor Insecten, Doubletten, d. K. Z. M., Berlin, 1829, p. 13.
rufescens Castelnau, Monogr. du genre Clytus, Paris, 1835, p. 16.
devastator Castelnau, Monogr. du genre Clytus, Paris, 1835, p. 17.

This species closely resembles *longipes* in coloration and arrangement of elytral pattern, but it is uniformly smaller in size and only the hind legs are excessively long. The pronotum is without fasciæ, sparsely gray or brown pubescent, evenly and densely punctate. Elytral markings: a transverse fascia across the base, thence down the suture to basal fourth where it joins an oblique fascia ascending toward the humerus again, this last sometimes terminated halfway back to the humerus; a small spot a little before the middle, near the suture; a transverse fascia at apical third, triangularly dilated at suture; a small sutural spot at apical fourth, sometimes connected along the

suture with the fascia at apical third; a pale apical patch. Five specimens before me from Florida and Cuba. Length, 5.5–12 mm.; breadth, 1.5–3.25 mm.

Hosts: *Punica granatum*, *Citrus*, and *Mangifera indica*.[27]

3. **Neoclytus scutellaris** Olivier.

(Plate III, Fig. 8.)

N. scutellaris Olivier, Encyclopedie Methodique Insectes, Bom-Cir., V, 1790, p. 266.
elegans Haldeman, Trans. Am. Phil. Soc. 2, X, 1847, p. 40.

Front of head bilineate with pale pubescence; a fascia in front of pronotal margin passing down behind the eyes; antennæ brown. Scutellum clothed. Elytral markings, as Haldeman remarks, "present the appearance of four separate quadrants placed together, with the convexity inwards." There is a slightly arcuate, oblique fascia at apical fourth; elytral bases brown overlaid with gray pubescence. Hind femora acutely spined. Nine specimens before me from Pennsylvania, Alabama, and Tennessee. Length, 7.5–12 mm.; breadth, 2–4 mm.

Host: *Quercus alba*.[28]

This species is closely allied to *N. mucronatus* but differs by the absence of red pronotal areas, the presence of a mid-pronotal fascia, and by having the first and second elytral fasciæ much closer together. *N. elegans* Hald. is the same as *scutellaris* Oliv.

4. **Neoclytus mucronatus** Fabricius.

(Plate III, Fig. 2.)

N. mucronatus Fabricius, Systema Entomologiae, Flensburg and Lipsiae, 1775, p. 193.
maculosus Gmelin, Ed. 13 of Linne's Systema Naturae, Lipsiae, 1790, p. 1854.
luscus Fabricius, Supple. Entomologia Systematica, Hafniae, 1798, p. 152.
humeralis Newman, Entom. Magaz., V, London, 1838, p. 394.
strictulus Casey, Mem. on Col., III, 1912, p. 369.

Front of head bilineate with yellow; antennæ light brown, darker distally; a fascia in front of pronotal margin passing down behind the eyes. Pronotum with two broad red-brown areas on the disc. Scutellum clothed. Elytral markings: a fascia from just behind the scutellum, along the suture to basal fourth, thence oblique backward to margin; an anteriorly arcuate fascia a little behind the middle; another, arcuate, oblique, at apical fourth. Tibiæ and tarsæ red-brown, femora darker, the hind pair black distally, acutely spined. Ten specimens before me from Texas and North Carolina. Length, 11–20 mm.; breadth, 3.25—6 mm.

---

[27]Craighead, N. A. Ceram. Larvae, 1923, p. 54.
[28]Craighead, N. A. Ceram. Larvae, 1923, p. 54.

Host: *Hicoria.*[29]

N. strictulus Csy., is a variety of *mucronatus* in which the red pronotal areas are absent, the scutellum more uniform, the carinules of the median ridge less evident. All of these characters are variable. There is one such specimen before me from Pennsylvania.

5. **Neoclytus irroratus** LeConte.

(Plate IV, Fig. 12.)

N. irroratus LeConte, Journ. Ac. N. S. Phila. 2, IV, 1858, p. 26.
morosus Chevrolat, Ann. Ent. Soc. Fr., 3rd Series, VIII, 1860, p. 501.

Dark brown to black, form robust. Antennæ thickened distally, basal joint rather large, joints three to six spined. Pronotal carinæ condensed into three rough longitudinal ridges, without fascia, sparsely covered with short gray hairs. Scutellum clothed. Elytra sparsely covered with short, gray pubescence; apices truncate, spined; markings in the form of a faint, deeply and narrowly undulating fascia a little behind the middle. Ventral surface uniformly, sparsely gray pubescent. Femora slim basally, suddenly clubbed distally and bispined. Five specimens before me from California and Arizona. It extends eastward into Texas and southward into Mexico. Length, 13–19 mm.; breadth, 3.5–5.5 mm.

6. **Neoclytus acuminatus** Fabricius.

(Plate III, Fig. 4.)

N. acuminatus Fabricius, Systema Entomologiae, Flensburg and Lipsiae, 1775, p. 194.
erythrocephalus Fabricius, Mantissa Insectorum, Hafniae, 1787, p. 156.
americanus Gmelin, Ed. 13 of Linne's Systema Naturae, Lipsiae, 1790, p. 1854.
aspericollis Germar, Insectorum sp. nov., Halae, 1824, XXIX, p. 517.

Head brown, antennæ brown basally, darker distally. Pronotum brown, apex and base darker. Base of elytra brown, remainder black, the truncature angles a little prolonged; markings: a short yellow pubescent patch at base and three straight fasciæ oblique backward from the suture, the last one almost transverse. Legs red brown, femora darker, the hind pair acutely but shortly spined. Sixteen specimens before me from Pennsylvania, New York, Illinois, Texas, Kansas, Missouri, and New Jersey. Length, 7–13 mm.; breadth, 2–4 mm.

Hosts: Elm, soft maple, black locust, and hickory.[30] Craighead gives a great many hosts.[31]

---

[29]Craighead, N. A. Ceram. Larvae, 1923, p. 54.
[30]Blatchley, Col. of Ind., p. 1038.
[31]Craighead, N. A. Ceram. Larvae, 1923, p. 55.

7. **Neoclytus torquatus** LeConte.

(Plate III, Fig. 12.)

N. torquatus LeConte, Smith. Misc. Coll., XI, 264, 1873, p. 200.

Ground color dark brown to black. Elytral bases pale pubescent. Markings: a fascia at basal fourth directed forward from the suture; middle and hind fasciæ oblique backward from suture, the middle one somewhat sinuate; a narrow apical patch. One specimen before me from Mr. Liebeck. Length, 11–15 mm. Type locality, Texas.

8. **Neoclytus peninsularis** Schaeffer.

(Plate III, Fig. 7.)

N. peninsularis Schaeffer, Bull. Brook. Inst. I, 1905, p. 133.

Ground color reddish-brown. Base of elytra pale pubescent; markings: a fascia at basal fourth, narrow, transverse; a fascia at middle, broad at suture, oblique backward, gradually narrowing toward the margin; a fascia at apical fourth, broad, oblique backward from suture; truncature angles slightly prolonged. Hind tibiæ shortly bispined. Two specimens before me from Mr. Schaeffer and Mr. Fall. Length, 7.5–14 mm.; breadth, 2–2.5 mm. Type locality Lower California.

9. **Neoclytus abbreviatus** Schaeffer.

(Plate IV, Fig. 15.)

N. abbreviatus Schaeffer, Bull. Brook. Inst. I, 1908, p. 340.

I have not seen this species. The figure was made from a sketch supplied by Mr. Schaeffer. The original description follows:

"Reddish-brown, elytra with three yellow fasciæ; the sub-basal one slightly below basal fourth, obliquely directed upwards from the suture, but suddenly abbreviated at middle of elytron and not reaching the side margin; the second fascia at middle, strongly angulate anteriorly near suture; third fascia at about apical third, posteriorly nearly parallel with the oblique apices, anteriorly rather suddenly dilated near suture. Head roughly sculptured. Thorax arcuate; disc with a median row of a few transverse tubercles and a few on each side, of which the sub-basal one is very prominent. Elytra slightly narrower behind middle; apices of posterior femora acute but not spinous. Posterior tibiæ feebly dilated and shallowly grooved on the inner and outer side. Length, 9 mm. Brownsville, Texas." (O. Dietz.)

10. **Neoclytus approximatus** LeConte.

(Plate IV, Fig. 11.)

N. approximatus LeConte, Proc. Ac. N. S. Phila., 1862, p. 42.

Ground color reddish-brown. Pronotum with a hair line of yellow pubescence basally. Elytral bases pale pubescent; a straight fascia at basal fourth, oblique backward from suture, broad at suture; a fascia

at middle near this last, oblique forward for a short distance, acutely angled, passing obliquely backward to margin; a fascia at apical fourth, oblique backward from suture, broad at suture. Ventral surface with conspicuous yellow patches on the mesepisterna, metepisterna, and first abdominal segment. Legs red brown. Seven specimens before me from Kansas. Length, 9–11 mm.; breadth, 2.5–3 mm. Type locality, Kansas.

11. **Neoclytus vanduzeei** Van Dyke.

(Plate IV, Fig. 13.)

N. vanduzeei Van Dyke, Pan-Pac. Ent., III, 1927, p. 107.

This species is very near LeConte's *N. approximatus*. Dr. Van Dyke says: "This elegant species belongs in the group with *approximatus*, *abbreviatus*, *peninsularis*, and *tenuiscriptus*, from all of which it differs by having the sub-basal and sub-apical yellow elytral bars triangularly dilated at suture." This is evidently an error, because *approximatus* has the same dilation of the elytral fasciæ mentioned. Dr. Van Dyke has since compared *vanduzeei* with a specimen of *approximatus* submitted to him, and he says that they are not the same species. The original description of *vanduzeei* follows:

"Elongate, subcylindrical; reddish-brown, sides and base of prothorax and base and apex of elytra definitely sprinkled with yellow hair; scutellum completely clothed with yellow pile; three elytral bands formed of the same pile, the sub-basal slightly behind basal fourth, almost transverse, narrowed outwardly, and triangularly enlarged at suture, the second at middle very oblique, broader and acutely angulate near suture, its sutural limb reaching backward to the suture, and the third near apex, oblique, broad and somewhat triangularly enlarged at suture; beneath with yellow patches on meso- and meta-epimeron,[32] and posterior margins of first and second abdominal segments. Head rather coarsely punctured and granulate; antennæ almost reaching middle of elytra, with segments 5–11 forming a narrow club. Prothorax longer than broad, slightly broader than elytra, narrowed at base and apex, sides scarcely arcuate; disk slightly, longitudinally cristate at middle, with a few transverse tubercles along crest and at sides, especially anteriorly and posteriorly. Elytra about two and one half times as long as prothorax, with straight sides gradually narrowing; apices obliquely truncate within, the angles sub-acute. Apex of posterior femora acutely toothed; the posterior tibiæ long, curved, slightly dilated outwardly and grooved on inner and outer side. Length, 11 mm.; breadth, 2.5 mm.

Holotype (No. 2450, Mus. Calif. Acad. Sci.,) a unique secured by Mr. E. P. Van Duzee at Nogales, Arizona, April 3, 1921."

[32]Dr. Van Dyke meant to say meso- and meta-episternum.

12. **Neoclytus tenuiscriptus** Fall.

(Plate III, Fig. 11.)

N. tenuiscriptus Fall, Journ. N. Y. Ent. Soc., XV, 1907, p. 82.

This species is very near *approximatus* but has characters which differ consistently and must, therefore, be regarded as a distinct species.

The color is red-brown. Pronotum without fasciæ. Elytral bases generally without pale pubescence, the elytral fasciæ placed as in *approximatus* but with the difference noted in the key. The truncatures of the elytral apices are narrower. Two specimens before me from Claremont, California, the type locality. Length, 12.5 mm.; breadth, 3.25 mm.

13. **Neoclytus interruptus** LeConte.

(Plate III, Fig. 16.)

N. interruptus LeConte, Smith. Misc. Coll., 264, 1873, p. 201.

Ground color deep cinnamon-brown. Pronotum with a triangular spot of yellow pubescence at middle of basal margin. Elytral markings: a lozenge-shaped transverse patch at basal fourth, attaining neither side nor suture; a fascia a little behind middle, lunate oblique; an oblique, slightly arcuate fascia at apical sixth. LeConte says, "elytral apices separately rounded," which is not exactly correct. There is a truncature, but the inner angle is somewhat rounded. One specimen before me from St. Helena, California. Length, 10–12 mm.; breadth, 3–3.5 mm. Type locality, California. The type does not seem to be in the LeConte collection.

14. **Neoclytus basillaris** Van Dyke.

(Plate V, Fig. 6.)

N. basillaris Van Dyke, Pan-Pac. Ent., V. 3, 1929, p. 136.
basalis Van Dyke, Pan-Pac. Ent., III, 1927, p. 106.

Apparently only the type is known. The figure was made from a drawing of the type done by Mrs. F. Abernethy and sent to me by Dr. Van Dyke. The name *basalis* was preoccupied by Chevrolat, Ann. Soc. Ent. Fr. (4) I. 1861, p. 384. The original description is as follows:

"Elongate, sub-cylindrical, moderately robust; rufous, pronotum brownish, margined anteriorly and posteriorly with narrow bands of yellow hair; elytra brown with three transverse bars of yellow pile, arranged as follows: a broad basal band occupying more than one-fourth of basal area and extending transversely from margin to margin; a post-median band broad at suture and rapidly narrowing toward margins, and a sub-apical of moderate breadth extending obliquely backward and outward from the suture on either side, and, like the

post median, not quite reaching the lateral margin; underside sparsely clothed with yellow pile, slightly more abundant at sides. Head rather closely, finely punctate in front and behind, but coarsely punctured just back of antennal tubercles, moderately sulcate between the antennæ; antennæ reaching at least three segments behind base of prothorax, with outer segments considerably enlarged, third segment hardly longer than fourth, and segments three and four but little more than three times as long as broad. Prothorax longer than broad, broader at apex than base, greatest breadth anterior to middle; sides rather evenly but not markedly arcuate; disc with longitudinal ridge evident but not well defined; surface rather finely, closely punctured, with series of asperities along summit at sides, and three evident transverse cristæ, the anterior back of apex, the others post median. Elytra almost three times as long, and barely broader than prothorax, about three times as long as broad; sides straight, slightly convergent posteriorly; apices angulate but rounded at tips; disc finely, closely punctate, rather sparsely clothed with brown pile on brown areas, and more densely with yellow pile on yellow areas. Length, 15 mm.; breadth, 3.75 mm."

"Holotype (No. 2448, Mus. Calif. Acad. Sci.), a specimen in my collection from Spokane, Washington, collected July 30, 1907, by Davidson."

15. **Neoclytus balteatus** LeConte.

(Plate III, Fig. 14.)

N. balteatus LeConte, Smith. Misc. Coll., **264**, 1873, p. 201.

Ground color cinnamon-brown to black. Pronotum margined with yellow pubescence, sometimes with a fascia at middle, often deficient or interrupted. Elytral markings usually yellow, placed as follows: a straight, transverse fascia at basal fourth; another straight transverse fascia a little behind middle, sometimes slightly dilated near the suture; a third fascia at apical fifth, oblique backward from the suture; a narrow apical patch. Ventral surface of males almost entirely covered with yellow pubescence, in the females posteriorly on the mesepisterna, metepisterna, and two or three abdominal segments. Six specimens before me from Northern California and one from near Princeton, British Columbia. One of the California specimens is a homotype compared by Mr. Ralph Hopping. Length, 8.5–15.5 mm.; breadth, 2–4 mm. Type locality, Oregon.

There are three specimens other than the type in the LeConte collection. The males are in some cases black in ground colour and in some collections these have been called *N. interruptus* Lec. There is some doubt as to whether these black forms are the male of *balteatus* and until mated sexes are taken to prove or disprove it, I prefer to consider them as such.

16. **Neoclytus provoanus** Casey.

(Plate V, Fig. 9.)

N. provoanus Casey, Mem. on Col., XI, 1924, p. 272.

There is one specimen of this before me from Keremeos, British Columbia, a homotype compared by Mr. Fisher.

It closely resembles *balteatus* but differs by having the first elytral fascia acutely prolonged forward near the margin. The antennæ are shorter and less thickened distally. The legs are more slender. Length, 9–13 mm.; breadth, 2.5–3.6 mm. Type locality, North Fork, Provo Canyon, Utah.

17. **Neoclytus angelicus** Van Dyke.

(Plate V, Fig. 7.)

N. angelicus Van Dyke, Pan-Pac. Ent., III, 1927, p. 107.

There are apparently only two specimens of this known, one in the California Academy of Sciences, and one in the Horn collection. They were taken in 1891 on the beach at Santa Monica, California. The figure was copied from a drawing of the type by Mrs. F. Abernethy. The original description is as follows:

"Elongate, sub-cylindrical, velvety black, legs and antennæ rufopiceous, the terminal segments of the latter darker; pronotum with a narrower band of white hair bordering anterior and posterior margins and a complete transverse band of white hairs across the middle; scutellum white; elytra with three transverse white bands, the first, one-fourth distant from base; the second sub-median and the third toward the apex, the last slightly oblique, barely touching suture and not reaching the lateral margins; underside with patches of white hair along the posterior pronotal margin, on the meso- and meta-epimeron,[33] and lateral posterior margins of ventral segments. Head moderately, finely, closely punctured, more coarsely just behind antennæ, giving the surface a granulate appearance, depressed between antennal tubercles; antennæ extending a few segments beyond posterior margin of prothorax, segments 5–11 considerably enlarged, third slightly longer than fourth, and almost four times as long as broad. Prothorax as broad as long, base and apex of about equal breadth, sides narrowed in front and back, slightly irregularly arcuate at middle; disk with median and lateral longitudinal ridges well marked, with small transverse rugæ on their summits; surface finely closely punctured. Elytra barely broader than prothorax, and about two and one half times as long; sides straight, rather finely closely punctured, and somewhat shining. Length, 10 mm.; breadth, 2.5 mm."

[33] Dr. Van Dyke meant to say meso- and meta-episternum.

18. **Neoclytus magnus** Schaeffer.

(Plate V, Fig. 5.)

N. magnus Schaeffer, Journ. N. Y. Ent. Soc., XII, 1904, p. 224.

There was no opportunity to see this species. The figure was made, from a drawing of a specimen in the Blaisdell collection, by Mrs. F. Abernethy and forwarded by Dr. Van Dyke. Mr. Schaeffer also supplied me with a sketch. The original description is as follows:

"Elongate, brown; thorax darker, at middle with a yellow white fascia, base, apex, and sides densely pubescent with white hairs; elytra with two straight and one oblique white fascia. Head very finely and very densely punctured, above the antennal tubercles and cheeks, coarsely punctured, antennæ reaching the first elytral fascia, joints three and four slender, the outer joints shorter and broader and gradually decreasing in length. Thorax as long as broad, base and apex equal, sides slightly arcuate, disk moderately, coarsely and densely punctured, with three rows of well defined transverse rugæ, one at middle, and one on each side below which the disk is depressed, those at side sinuate at side and oblique at base. Elytra two and a half times as long as broad, narrower than the thorax at middle, sides nearly straight, slightly narrowing to apex which is arcuate truncate, the sutural angle rounded, the outer slightly acute. Beneath clothed with white hairs, denser at sides of prosternum, meta-sternum, and abdomen, the latter finely and densely punctured. Legs long and slender, femora without spines, hind tibiæ and tarsi compressed, first joint of hind tarsi longer than the following ones together. Length, 20 mm. Ensenada, Lower California."

19. **Neoclytus modestus** Fall.

(Plate III, Figs. 5, 6.)

N. modestus Fall, Journ. N. Y. Ent. Soc., XV, 1907, p. 81.
carus Fall, Journ. N. Y. Ent. Soc., XV, 1907, p. 81.
modestus zebratus Van Dyke, Pan-Pac. Ent., III, 1927, p. 108.

N. modestus and *N. carus* were found by Mr. Alonzo Davis, of Pasadena, Cal., to be male and female, respectively, of the same species; Mr. Davis reared numbers of them and took several pairs in copulation.

The female is black or dark brown, with yellow or white fasciæ. The pronotum is generally margined with yellow and there is sometimes a median transverse fascia, interrupted at the middle. Elytral markings: a fascia at basal fourth, slightly arcuate, oblique; a fascia at middle, quite deeply arcuate; and a fascia, slightly arcuate, oblique, at apical fourth. In the male the pronotum is without distinct fascia and the elytral markings are sometimes clouded by a sprinkling of sparse gray pubescence. Ten females and fourteen males before me from Mendocino, Plumas, and Tulare Counties, and Pasadena, California; one, a

paratype male. Length, 9.5–10.5 mm.; breadth, 2.5–2.75 mm. Type locality, Pasadena, California; paratype male, Kaweah, California.

N. modestus zebratus Van Dyke, was described as differing from true *modestus* mainly by the absence of white patches on the "meso-epimera" and but a slight amount on the "meta-epimera." Dr. Van Dyke advises me that this should have read "meso-episterna," and "meta-episterna." The female of this subspecies has the markings somewhat narrower and white instead of yellow. It is supposed to inhabit Northern California, while true *modestus* occurs in the southern part of the state. Type locality, Meadow Valley, Plumas Co., California. Two paratypes, male and female, examined from type locality. It is felt that this subspecies is somewhat superfluous, since there is a female before me from Mendocino Co. with the markings of the usual yellow colour. There is considerable variation in this species.

20. **Neoclytus muricatulus** Kirby.

(Plate III, Fig. 3.)

N. muricatulus Kirby, Ins. in Rich. Fauna Bor. Am., IV, London, 1837, p. 177.
leucozonus Castelnau, Monogr. du genre Clytus, Paris, 1835, p. 90.
muricatus Provancher, Faune Ent. Canada, I, 1877, p. 601.

A small species, ground color brown to black, with white markings. Antennæ slender, pronotum without distinct fascia, sometimes with two faint spots on the disc. Elytral markings: a parenthesis extending across the base of the elytron, down the suture to basal fourth, thence curving outward to margin, sometimes interrupted, leaving a marginal dot; a mid-fascia oblique backward from suture, slightly arcuate; apical patch absent. Ventral surface with condensed pubescence posteriorly on the mesepisterna and first two or three abdominal segments. This is a common species, occurring from the Atlantic to the Pacific. Sixty-two specimens before me from practically all parts of its range. Length, 7–11.5 mm.; breadth, 1.75–4 mm.

Hosts: *Picea, Pseudotsuga, Pinus, Larix.*[34]

21. **Neoclytus infans** Casey.

(Plate IV, Fig. 10.)

N. infans Casey, Mem. on Col., III, 1912, p. 368.

This species is near *muricatulus* and Dr. Van Dyke thinks it is but a local form of that species. It may eventually prove to be so, but the characters by which it may be distinguished from *muricatulus* appear to be constant.

[34]Craighead, N. A. Ceram. Larvae, 1923, p. 55.

In addition to the difference mentioned in the key, the pronotum is less muricate, more evenly punctate, and the antennæ are more slender. The elytral bases are often lighter brown than the remainder. Seventeen specimens before me from Northern California and Southern Oregon. Length, 9.5–10.5 mm.; breadth, 2.5–2.75 mm. Type locality, Siskiyou Co., California.

22. **Neoclytus ascendens** LeConte.

N. ascendens LeConte, Bull. U. S. Geol. and Geog. Suv., IV, 1878, p. 462.

There is one specimen of this before me, a homotype compared by Mr. Ralph Hopping. It is possibly a variation of *muricatulus*, but until more material is available, the markings are distinctive enough to retain it as a distinct species.

The antennæ are slender, not appreciably thickened distally. Pronotum without fascia, less muricate than in *muricatulus*. Elytral markings as in *muricatulus* with the addition of a fascia extending forward from the end of the mid-fascia, keeping near the margin, ending when half way to the humerus. Ventral surface much as in *muricatulus*. Length, 8–10 mm.; breadth, 2.5 mm. Type locality, Florissant, Colorado (8000 ft.). The specimen before me was taken, with a series of *muricatulus*, on telegraph poles at Edmonton, Alberta, by Mr. F. S. Carr.

The host tree is supposed to be spruce.

23. **Neoclytus kirbyi** Aurivilius.

(Plate III, Fig. 1.)

N. kirbyi Aurivilius, Junk Col. Cat. pars 39, 1912, p. 392.
longipes Kirby, Ins. in Rich. Fauna Bor. Am. IV, London, 1837, p. 176.
fulguratus Casey, Mem. on Coleop., III, 1912, p. 367.

Form slender, elongate. Pronotum without fascia, distinctly longer than wide. Elytral markings: a pale pubescent patch at base; a sutural and marginal dot. A fascia at middle, slightly arcuate or angulate, not attaining margin; an oblique arcuate fascia at apical fifth, somewhat irregular and angulate. Six specimens before me from Pennsylvania and Virginia. Length, 6.5–9 mm.; breadth, 2–4 mm.

Host: *Quercus*.

LeConte remarked that he has seen *N. longipes* Kirby, in Parisian collections under the name *N. fulguratus* Thomson.[35] I have not found any other reference to *N. fulguratus* Thomson.

N. fulguratus Csy., is described as a subspecies of *kirbyi*. It differs from the latter by the absence of the rhombus at basal elytral fourth. Mr. W. S. Fisher says of this: "Casey's specimen of *N. fulguratus* is somewhat different from his

[35] LeConte, Smith. Misc. Coll., XI, 264, 1873, p. 200.

specimen of *N. kirbyi*, but this may only be a variation and he certainly has not seen the type of *kirbyi*."

24. **Neoclytus jouteli** Davis.

(Plate III, Fig. 15.)

N. jouteli Davis, Ent. News, XV, 1904, p. 34.
simplarius Blatchley, Can. Ent., XLIX, 7, 1917, p. 240.

This is the smallest species of *Neoclytus*, superficially resembling some of the *Anaglypti* group.

Ground color black, with but two elytral fasciæ, oblique backward from suture, the hind one broad toward the suture. Two specimens before me from Virginia. Length, 6 mm.; breadth, 1.75 mm.

One specimen of *N. simplarius* Blatchley, was sent to me by Mr. Blatchley. I can see no difference between this and *jouteli* except in color. The ground color of *N. simplarius* is reddish brown. The specimen is from Florida. Type locality, Dunedin, Florida.

25. **Neoclytus conjunctus** LeConte.

(Plate III, Fig. 9.)

N. conjunctus LeConte, Rep. of Expl. and Surv. Miss. to Pac., XII, 1857, p. 61.
occiduus Casey, Mem. on Col., III, 1912, p. 369.
tularensis Casey, Mem. on Col., III, 1912, p. 369.

A common species in western North America from Vancouver Island to Southern California. The ground color is dark brown to black with yellow or gray markings. Pronotum with sides strongly arcuate and a suggestion of a fascia along apical margin. Scutellum naked. Elytral apices as described in the key; markings: a parenthesis from the basal margin, bordering the scutellum and down the suture to basal fourth, thence diverging from suture and passing forward to form a hook; another shorter parenthesis opposite this first one, on the margin; a fascia at middle passing forward then curving backward, passing obliquely to margin, slightly hooked at outer end and sometimes interrupted, leaving a marginal spot. This fascia is connected along the suture with one at apical fourth which is a short oblique dash, with a marginal spot opposite. The head, prothorax, ventral surface and legs are sparsely covered with long erect pubescence. Fifty-seven specimens before me from all parts of its range. Length, 7–17 mm.; breadth, 2.5–5 mm.

Hosts: *Fraxinus, Quercus, Arbutus, Pyrus.*[36]

Occiduus Casey and *tularensis* Csy. are the same as *conjunctus*. *Tularensis* is from the *conjunctus* series in the Hopping collection.

[36]Craighead, N. A. Ceram. Larvae, 1923, p. 54.

26. **Neoclytus caprea** Say.

(Plate III, Fig. 10.)

N. caprea Say, Journ. Ac. N. S. Phila., III. 1823, p. 424.
gibbicollis Castelnau, Monogr. du genre Clytus, Paris, 1835, p. 24.
elevatus Castelnau, Monogr. du genre Clytus, Paris, 1835, p. 32.

Pronotum with a narrow fascia along apical margin, sometimes interrupted at middle. Elytral markings: practically an entire circle occupying basal fourth, sometimes interrupted to form parentheses; a fascia near middle, anteriorly arcuate near suture, thence passing obliquely backward to margin; a straight oblique fascia at apical fourth. The long sparse vestiture on the head, prothorax, ventral surface, and legs is much as in *conjunctus*. Thirteen specimens before me from Pennsylvania, Ohio, Texas, and Kansas. Length, 8.5–17 mm.; breadth, 2.25–4.75 mm.

Hosts: *Fraxinus, Ulmus, Hicoria.*[37]
Craighead records *Fraxinus, Quercus,* and *Prosopis.*[38]

Genus **Euryscelis** Chevrolat.

Ann. Soc. Ent. Fr., 4th Series, II, 1862, p. 530.
Genotype (*Callidium*) *suturale* Olivier.

Chevrolat says: "This genus was established by Dejean principally for the character of having twelve jointed antennæ." This statement seems to indicate that Dejean is the author of this genus, but apparently he has published no "indication" as defined by the International Rules of Zoological Nomenclature.

1. **Euryscelis suturalis** Olivier.

(Plate IV, Fig. 4; Plate V, Fig. 11.)

E. suturalis Olivier, Entomologie IV, 70, 1795, p. 62.
dejeani Chevrolat, Ann. Soc. Ent. Fr., 4th Series, II, 1862, p. 530.
megalopus Casey, Mem. on Col., XI, 1924, p. 271.
subtropica Casey, Mem. on Col., XI, 1924, p. 271.

Form elongate, cylindrical, red-brown. Front of head bilineate with pale pubescence and a fascia in front of the pronotum passing down behind the eyes; antennæ about half the body length, reddish brown basally, black distally. Pronotum without clear cut fascia, sparsely gray pubescent, with individual transverse carinæ as in *Neoclytus*. Scutellum clothed. Elytral markings in the form of a triangle, occupying basal fourth, the side of the triangle lying along the suture produced along the suture to the middle where it joins a

[37]Blatchley, Col. of Ind., 1913, p. 1039.
[38]Craighead, N. A. Ceram. Larvae, 1923, p. 54.

transverse fascia extending to margin; a small marginal dot at basal fourth and a broad lunate patch occupying almost the entire apex. In the male, these markings are often reduced to a broad fascia down the suture with dilations basally, at middle, and at apex. The elytral apices are truncate, the angles somewhat produced. Ventral surface with sparse gray pubescence, and condensed patches posteriorly on the mesepisterna, metepisterna, metasternum, and laterally on the abdominal segments. Middle and hind legs long, especially the latter, the femora slender until near the outer end where they are suddenly clubbed and acutely spined; front femora with a row each, of well developed saw teeth on the under side, a character which is evident in a few species of *Neoclytus*, such as *N. torquatus*. Three specimens before me, a male and two females, from Florida and Santa Domingo. Length, 12–15 mm.; breadth, 3–4 mm.

E. megalopus Csy. and *subtropica* Csy. are probably individual variations of *suturalis*. Mr. W. S. Fisher has kindly given me the following note on these after studying the types: "Casey does not have *Euryscelis suturalis* Oliv. in his collection, and only has a single example each of *megalopus* and *subtropicus*, which only differ slightly from each other. I have a large series of *suturalis* from the West Indies and the southern part of Florida, and the specimens show extreme variation, especially in the sexes. I believe it is only a single species and is distributed throughout the extreme southern part of Florida and part of the West Indies."

Genus **Clytus** Laicharteg.

Verz. u. Beschr. der Tyroler Ins. Zurich, 1784, p. 88.

Type by subsequent designation, (*Cerambyx*) *arietis* Linne, (Curtis, British Entomology, V, 1828, p. 199). Type again cited by Westwood (Syn. of Gen. British Insects, 1840, p. 40).

In Boreal America, this genus is represented by seven species. They are usually rather small in size, the length as a rule a little more than three times the width of body. The antennæ are not more than half the body length, uniform or slightly thickened distally. The prothorax is as wide or wider than long, the pronotum without individual carinæ, although it may, in some cases, approach the carinulate. The scutellum is clothed in all of our species. The elytra are variously banded with gray or yellow, the base distinctly wider than the prothorax, margins usually subparallel, apices feebly truncate to rounded. The femora are moderately clubbed and do not have distal spines.

CLYTUS, SPECIFIC KEY.

A. Pronotum margined with yellow or gray fascia.
  B. Elytral fascia at basal third deeply arcuate.
    C. Fascia at apical third oblique. (Page 562).....1. **ruricola**
    CC. Fascia at apical third transverse or nearly so. (Page 563)..3. **planifrons**
  BB. Fascia at basal third shallowly arcuate.
    C. Elytral surface opaque. (Page 563).....4. **marginicollis**
    CC. Elytral surface shining.
      D. Length almost four times the width. (Page 563).....2. **pacificus**
      DD. Length a little over three times the width. (Page 564)..5. **blaisdelli**
AA. Pronotum without fasciae.
  B. Elytral fascia at basal third a broad saddle, the anterior and posterior fascial margins irregular, ragged. (Page 564).....6. **clitellarius**
  BB. Fascia at basal third arcuate oblique from near the scutellum backward and outward to margin, narrow and clear cut. (Page 565)...7. **canadensis**

1. **Clytus ruricola** Olivier.

(Plate IV, Fig. 9.)

C. ruricola Olivier, Entomologie, IV, Paris, 1795, p. 65.
hamatus Say, Journ. Ac. N. S. Phila., III, 1823, p. 423.
capreolus Dejean, Cat. 3rd Ed., 1837, p. 356.
catulus Casey, Mem. on Col., III, 1912, p. 370.

Form elongate, brown to black. Head densely and coarsely punctate; antennæ light brown basally, darker distally. Pronotum margined with yellow, often interrupted basally. Elytra with apices narrowly subtruncate; markings: a subhumeral dash, slightly oblique; a fascia beginning near the suture at basal fifth, running backward, slightly diverging from suture, curving outward and forward at a little more than basal third, ending in a marginal dilation; a fascia at apical third, slightly arcuate, oblique backward from suture; sometimes a faint apical patch of gray. Ventral surface with yellow pubescent patches posteriorly on the mesepisterna, metepisterna, front and hind margins of metasternum and posterior margins of abdominal segments. Femora reddish-brown basally, black distally, clubbed, the middle pair excessively so in the male; tibiæ and tarsæ red-brown. Eleven specimens before me from New York, Ohio, Michigan, and Quebec. Length, 10–14 mm.; breadth, 3–4 mm.

Hosts: *Acer*, *Hicoria*, *Sorbus*, *Betula*, and *Fagus*.[39]

C. catulus Csy. appears to be an imperfect specimen of *ruricola*. Mr. L. L. Buchanan says of this: "In most specimens of *ruricola*, the sutural lines of pale pubescence (referring to fasciæ at basal third) diverge from base backwards, while in *catulus*, these lines are broader and sub-parallel. These lines are incomplete in *catulus*, probably due to abrasion. If complete they might diverge as in *ruricola*. The form of body in *catulus* is more oblong and less tapering than in *ruricola*, though some specimens of the latter species can be found with

[39]Craighead, N. A., Ceram. Larvae, 1923, p. 59.

the body outline practically identical. I cannot detect any difference in the antennæ or legs of the two species."

2. **Clytus pacificus** Van Dyke.

(Plate IV, Fig. 7.)

C. pacificus Van Dyke, Bull. Brook. Ent. Soc., XV, 1920, p. 38.

This is smaller than *ruricola*, but is similarly elongate in form. The ground color is brown. Head densely and rather coarsely punctate; antennæ reddish-brown, darker distally. Pronotum densely and coarsely punctate, margined with yellow or gray pubescence which is sometimes absent basally. Elytral margins subparallel, apices feebly truncate; markings: a sub-humeral dot; a lunate fascia beginning near suture at basal third, curving backward and outward in a shallow arcuation to margin; a fascia at apical third, slightly oblique backward from suture. Ventral surface with gray pubescent patches posteriorly on the mesepisterna, metepisterna, and abdominal segments. Femora dark brown, tibiæ and tarsi lighter. Type locality, Mary's Peak, Corvallis, Oregon. Two metatypes before me from British Columbia. Length, 9 mm.; breadth, 2.5 mm.

Host: *Pseudotsuga taxifolia.*

3. **Clytus planifrons** LeConte.

(Plate IV, Fig. 5.)

C. planifrons LeConte, Trans. Am. Ent. Soc., V, 1874, p. 67.

Ground color black. Front of head bilineate with yellow; antennæ brown basally, darker apically. Pronotum margined with yellow and sparsely covered with long erect pubescence. Elytral markings: a short subhumeral dash, slightly oblique; a deeply arcuate fascia at apical third; a broad apical patch. Ventral surface with condensed pubescence posteriorly on the mesepisterna, metepisterna, and broadly on the abdominal segments. Legs brown. Twenty-eight specimens before me from British Columbia, Oregon, and California. Length, 8–13 mm.; breadth, 2.5–4 mm.

4. **Clytus marginicollis** Castelnau.

(Plate IV, Fig. 6.)

C. marginicollis Castelnau, Monogr. du genre Clytus, Paris, 1835, p. 41.
vespoides Haldeman, Trans. Am. Phil. Soc. (2), X, 1847, p. 40.
carolinensis Casey, Mem. on Col., III, 1912, p. 372.

Head and prothorax with sparse long pubescence; antennæ brown, darker distally. Elytral markings: a shallowly arcuate, oblique fascia at basal third; a fascia at apical third, nearly transverse; and a narrow apical patch. Ventral surface with condensed pubescence posteriorly on the mesepisterna, metepisterna, and narrowly on the abdominal segments. Two specimens before me from New Hampshire and Maine. Length, 8–10 mm.; breadth, 2–2.5 mm.

Host: *Pinus virginiana*.[40]

C. carolinensis Csy., seems to be a geographical race and probably deserves subspecific rank. It differs from typical *marginicollis* by having the base of the elytra, legs, and antennæ pale brown and by having longer hairs on the head and prothorax. The markings are the same as in *marginicollis*. Type locality Southern Pines, North Carolina. One specimen before me from Virginia.

5. **Clytus blaisdelli** Van Dyke.

(Plate IV, Fig. 16.)

C. blaisdelli Van Dyke, Bull. Brook. Ent. Soc., XV, 1920, p. 39.

Fasciæ gray or yellow, head and prothorax black, elytra and legs dark brown. Elytral markings: a subhumeral dash, slightly oblique; a slightly arcuate fascia at basal third, almost transverse, sometimes rising slightly near the suture, generally not attaining margin or suture; a transverse short fascia at apical third; and a faint apical patch. Ventral surface with condensed pubsecence posteriorly on the mesepisterna, metepisterna, and abdominal segments. Two specimens before me from Trinity and Mendocino Counties, California, one a metatype. Type locality Carrville, Trinity County, California. Length, 9 mm.; breadth, 3 mm.

6. **Clytus clitellarius** Van Dyke.

(Plate V, Fig. 8.)

C. clitellarius Van Dyke, Bull. Brook. Ent. Soc., XV, 1920, p. 40.

Color dark brown, antennæ and legs lighter, with long sparse, erect hairs on the head, prothorax, elytral bases, and ventral surface; in addition a shorter, appressed vestiture on head, pronotum, and elytra. Pronotum without a clear cut fascia, somewhat carinulate but without individual carinæ. Elytra with parallel margins, apices feebly truncate, practically rounded; markings: a broad saddle at basal third, with front and hind margins irregular, ragged; two small dots on each elytron at apical third and a faint apical patch. One specimen before me from Yosemite Valley, California, sent by Dr. Van Dyke. Type locality, Fallen Leaf Lake, Tahoe, California. Length, 9.5 mm.; breadth, 3.25 mm.

This species was described as a *Neoclytus* but its shorter form and absence of definite individual pronotal carinæ place it much nearer *Clytus*.

---

[40]Craighead, N. A. Ceram. Larvae, 1923, p. 56.

7. **Clytus canadensis** G. Hopping.

(Plate IV, Fig. 8.)

C. canadensis Hopping, Can. Ent., LX, 1928, p. 246.

Head and prothorax dull black; elytra, antennæ, and legs dark shining brown. Pronotum without fasciæ. Elytral markings: a short, faint, subhumeral dash; a fascia beginning at suture just behind the scutellum, passing steeply, obliquely backward, gradually curving to margin at basal third; a fascia at apical third beginning at suture, slightly arcuate oblique to margin; elytral apices rounded, faintly tipped with gray pubescence. Ventral surface with condensed gray patches on the posterior portions of the mesepisterna, metepisterna, and abdominal segments. Length, 7–8.5 mm.; breadth, 2–2.4 mm. Sixteen specimens before me from Southern British Columbia. Type locality, Lumby, British Columbia.

Genus **Triodoclytus** Casey.

Mem. on Col. III, 1912, p. 350–351 and IV, 1913, p. 387.

Type by original designation, (*Clytus*) *lanifer* LeConte.

This genus was erected under the name *Paraclytus*, but since this name was preoccupied by Bates (Journ. Linn. Soc. Lond. Zool. XVIII, 1884, p. 234) Casey subsequently changed it.

The most important characters enumerated by Casey are the large emargination of the eyes, short front, tapering antennæ, and prothorax tubulated at base. The metepisternum is narrow, the tarsal joints very short.

This genus may eventually either revert to the Mexican genus *Ochraethes* or some of the species of *Ochraethes* may be placed under *Triodoclytus*, as they are apparently congeneric. Such species are *O. brevicornis* Chev. and *O. virescens* Chev. There are nine species of *Ochraethes* before me; the variation is considerable, some having subsutural carinæ and spined elytral apices as in some *Cyllene* while others are like *Triodoclytus* in these respects.

1. **Triodoclytus lanifer** LeConte.

(Plate IV, Fig. 3.)

T. lanifer LeConte, Smith. Misc. Coll., 264, 1873, p. 198.
brevitarsis Casey, Mem. on Col., III, 1912, p. 375.
crucialis Casey, Mem. on Col., III, 1912, p. 375.

In addition to the characters mentioned above, the body is clothed with long yellow pubescence. Antennæ brown, darker basally. Elytral

apices subacuminate, the elytral markings obviously in the chitin; markings: a triangular pale patch at base extending down the suture to apical fifth, thence oblique forward to humerus; a narrow transverse band at about the middle, slightly arcuate anteriorly, this sometimes reduced to short sutural offshoots; entire suture pale and a narrow oblique fascia at apical sixth, sometimes reduced to a short sutural offshoot. Femora brown basally, black distally; tibiæ and tarsi brown. Nineteen specimens before me from Napa County to Fresno County, California. It extends into Arizona and probably into Mexico. Length, 9–12 mm.; breadth, 2.5–4 mm. Type locality, Owen's Valley, California.

T. brevitarsis Csy. and *T. crucialis* Csy., are the same as *T. lanifer* Lec. None of the differences enumerated are of any value. After examining the types, Mr. W. S. Fisher says: "Casey does not have a specimen of *Triodoclytus lanifer* Lec. in his collection, but his *crucialis* and *brevitarsis* are only vaguely different and are similar to your specimens (Hopping collection) and also the specimens I have in our collection under *lanifer*. In a series of specimens of this species considerable variation can be found and since Casey did not seem to know *lanifer*, I believe both of his species will prove to be synonyms."

Genus **Clytoleptus** Casey.

Mem. on the Col., III, 1912, p. 350.

Type by original designation, *Clytus albofasciatus* Castelnau.

Anthoboscus Mulsant, Col. Fr. Long. ed. 2, 1863, p. 166.
Clytus Thomson, Skand. Col., VIII, 1866, p. 39.
Clytanthus Lacordaire, Gen. Col., IX, 1869, p. 68.
Caloclytus Gahan, Fauna Brit. In. Col. I, 1906, p. 260.

This genus is represented by one species in our fauna.

1. **Clytoleptus albofasciatus** Castelnau.

(Plate V, Fig. 10.)

C. albofasciatus Castelnau, Monogr. du genre Clytus, Paris, 1835, p. 96.
gracilicornis Casey, Mem. on Col., III, 1912, p. 371.
tristis Casey, Mem. on Col., III, 1912, p. 371.

Typically with head and prothorax black, posterior third of elytra behind the second fascia, and abdomen, dark brown. Antennæ over half the body length, dark basally, the third and fifth joints considerably longer than the fourth. Elytral markings: a gray fascia at basal third oblique backward from suture, narrow, sometimes almost obsolete; a gray fascia a little before apical third, arcuate oblique from suture backward; a faint apical gray patch. Eight specimens before me from Illinois, Kansas, and Pennsylvania. Length, 7–8 mm.; breadth, 1.75 to 2.25 mm.

Casey's *C. gracilicornis* appears to be the same as *C. albofasciatus*, and *tristis* only a variety. *C. tristis* is described as being entirely black with other minor differences. Hamilton has made this observation on *albofasciatus*:[41] "*Clytanthus albofasciatus* Lap. is raised both from grape vines and hickory limbs. There are two color forms produced indiscriminately that are so different in appearance that judged by color alone, would form two species. The one is entirely black with the usual anterior and posterior white bands on the elytra; the other is black with the antennæ brown; the part of the elytra anterior to the posterior white band, the femora, the coxal part of the prosternum, the meso- and metasternum, rufous." Casey's *C. tristis* is evidently the black form mentioned by Hamilton.

BIBLIOGRAPHY.

Aurivillius, C. Coleopterorum Catalogus, Pars 39, Schenkling Series, 1912.
Blatchley, W. S. Coleoptera of Indiana, 1913.
Casey, Thomas L. Memoirs on the Coleoptera III, 1912; IV, 1913; XI, 1924.
Castelnau. Monogr. du genre Clytus, Paris, 1835.
Chevrolat, L. A. Auguste. Ann. Ent. Soc. Fr., 3rd Series, VIII, 1860; 4th Series, II, 1862.
Craighead, F. C. N. A. Ceram. Larvae, Can. Dept. of Agr. Bull. 27, N. S., 1923.
Curtis, John. British Entomology, 1824–1839.
Fabricius, Johann C. Systema Entomologiae, 1775; Mantissa Insectorum, 1787; Suppl. Entomologia Systematica, 1798.
Haldeman, S. S. Trans. Amer. Phil. Soc. (2), X, 1847.
Horn, Geo. H. Synonymy of the Col. in Faun. Bor. Am., Can. Ent., VIII, 1876, p. 116. Trans. Amer. Ent. Soc., VIII, 1880, p. 134.
Kirby, Rev. William. Rich. Faun. Bor. Am., 1837.
LeConte, J. L., and Horn, Geo. H. Class. of the Col. of N. A., 1883.
Leng, Charles W. Syn. of the Ceram. Ent. Am., VI, 1890. Cat. of the Col. of Am. North of Mexico, 1920.
Leng, Charles W., and Mutchler, A. Supplement to above, 1927.
Linne, Carl Von. Systema Naturae, 1790.
Olivier, Antoine G. Entomologie, Paris, 1795.
Say, Thomas. Say's Entomology, edited by J. L. LeConte, 1895.
Westwood, John O. Syn. of Gen. British Insects, 1840.

[41]Hamilton, Can. Ent., XVIII, 1886, p. 113.

EXPLANATION OF PLATE I.

A. First abdominal segment showing intercoxal process. 1. *Cyllene, Glycobius, Calloides, Arhopalus.* 2. *Tylcus.* 3. *Xylotrechus.* 4. *Neoclytus, Euryscelis, Triodoclytus, Clytoleptus.*

B. Prosternal intercoxal process. 5. *Cyllene.* 6. *Tylcus, Calloides, Glycobius.* 7. *Arhopalus.*

C. Head of *Xylotrechus* showing types of frontal carinae. 8. Carinae Y-shaped. 9. Carina lozenge-shaped.

D. Antennae of Clytini. 10. *Glycobius.* 11, 12. *Cyllene.* 13. *Tylcus.* 14. *Calloides.* 15. *Arhopalus.* 16, 17, 18. *Neoclytus.* 19. *Euryscelis.* 20. *Triodoclytus.* 21. *Clytoleptus.*

E. 22. Elytron showing placement of subsutural carina in *Cyllene* and *Tylcus.*

F. Metepisterna showing relative breadth. 23. *Triodoclytus.* 24. *Clytus.* 25. *Clytoleptus.*

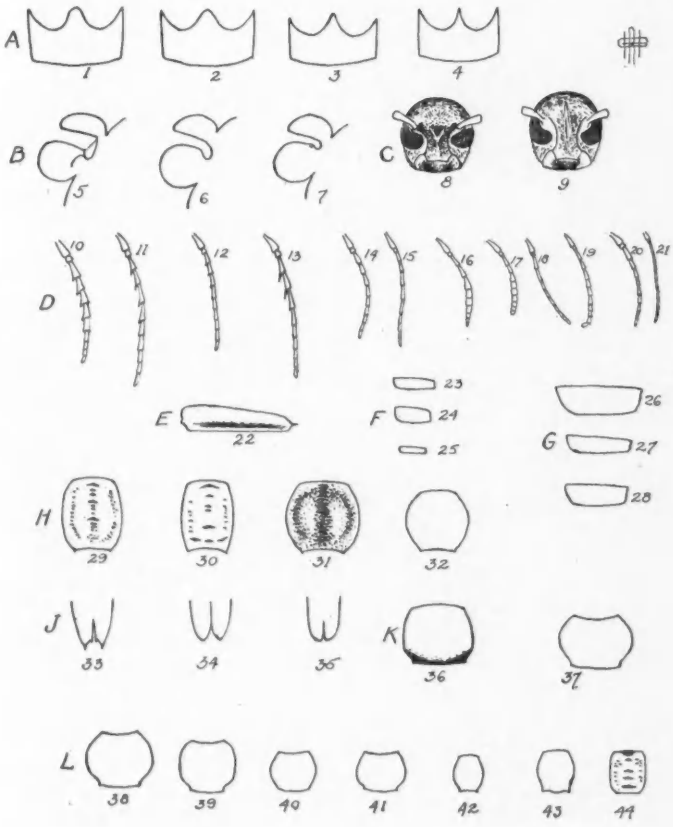
G. Metepisterna showing relative breadth. 26. *Calloides.* 27. *Arhopalus.* 28. *Tylcus.*

H. Prothorax. 29, 30, 31. *Neoclytus* showing types of carinae. 32. *Clytus.*

J. Elytral apices of *Neoclytus.* 33. Truncate, acutely spined. 34. Separately obtusely angulate. 35. Apices strongly and evenly rounded toward suture, meeting the sutural line subacutely.

K. Prothorax. 36. *Cyllene,* showing excavation basally. 37. *Glycobius.*

L. Prothorax. 38. *Calloides.* 39. *Tylcus.* 40. *Arhopalus.* 41. *Xylotrechus.* 42. *Clytoleptus.* 43. *Triodoclytus.* 44. *Euryscelis.*


A
1
2
3
4
B
5
6
7
C
8
9
D
10
11
12
13
14
15
16
17
18
19
20
21
E
22
F
23
24
25
G
26
27
28
H
29
30
31
32
J
33
34
35
K
36
37
L
38
39
40
41
42
43
44

EXPLANATION OF PLATES II TO V.

Plate II.

Fig.
1. *Xylotrechus colonus* Fab. × 2.
2. *Xylotrechus sagittatus* Germ. × 2.
3. *Xylotrechus undulatus* Say. × 2½.
4. *Xylotrechus fuscus* Kby. × 2½.
5. *Xylotrechus quadrimaculatus* Hald. × 2.
6. *Xylotrechus annosus* Say. × 2.
7. *Xylotrechus nauticus* Mann. × 2.
8. *Xylotrechus convergens* Lec. × 2.

Fig.
9. *Xylotrechus aceris* Fisher. × 2.
10. *Xylotrechus abietis* ♂ Van Dyke. × 2.
11. *Xylotrechus abieties* ♀ Van Dyke. × 2.
12. *Xylotrechus mormonus* ♀ Lec. × 2.
13. *Xylotrechus insignis* ♂ Lec. × 2.
14. *Xylotrechus insignis* ♀ Lec. × 2½.
15. *Xylotrechus nunenmacheri* Van D. × 2.
16. *Xylotrechus obliteratus* Lec. × 2.

Plate III.

Fig.
1. *Neoclytus kirbyi* Auriv. × 2.
2. *Neoclytus mucronatus* Fab. × 1½.
3. *Neoclytus muricatulus* Kby. × 1½.
4. *Neoclytus acuminatus* Fab. × 1½.
5. *Neoclytus modestus* ♂ Fall. × 1½.
6. *Neoclytus modestus* ♀ Fall. × 1½.
7. *Neoclytus peninsularis* Schffr. × 1½.
8. *Neoclytus scutellaris* Oliv. × 1½.

Fig.
9. *Neoclytus conjunctus* Lec. Natural size.
10. *Neoclytus caprea* Say. Natural size.
11. *Neoclytus tenuiscriptus* Fall. × 1½.
12. *Neoclytus torquatus* Lec. × 1½.
13. *Neoclytus cordifer* Klug. × 1½.
14. *Neoclytus balteatus* Lec. Natural size.
15. *Neoclytus jouteli* Davis. × 2.
16. *Neoclytus interruptus* Lec. × 1½.

Plate IV.

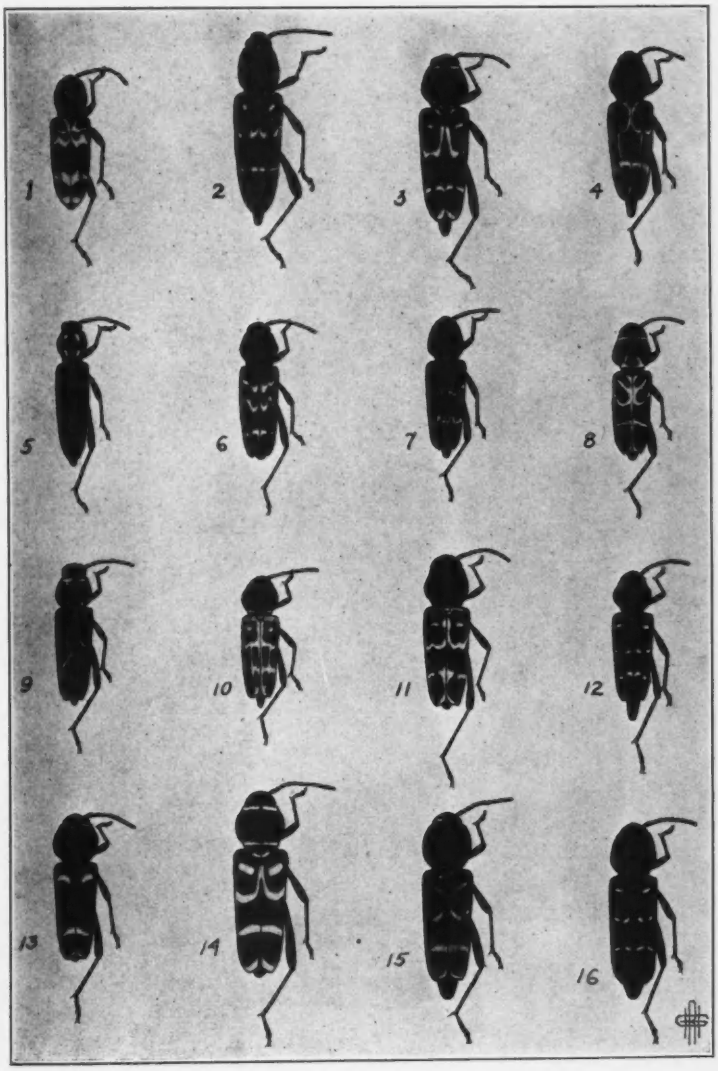
Fig.
1. *Xylotrechus quercus* Schffr. × 3.
2. *Xylotrechus lengi* Schffr. × 3.
3. *Triodoclytus lanifer* Lec. × 3.
4. *Euryscelis suturalis* ♀ Oliv. × 2½.
5. *Clytus planifrons* Lec. × 3.
6. *Clytus marginicollis* Cast. × 2½.
7. *Clytus pacificus* Van D. × 3.
8. *Clytus canadensis* G. Hop. × 3½.

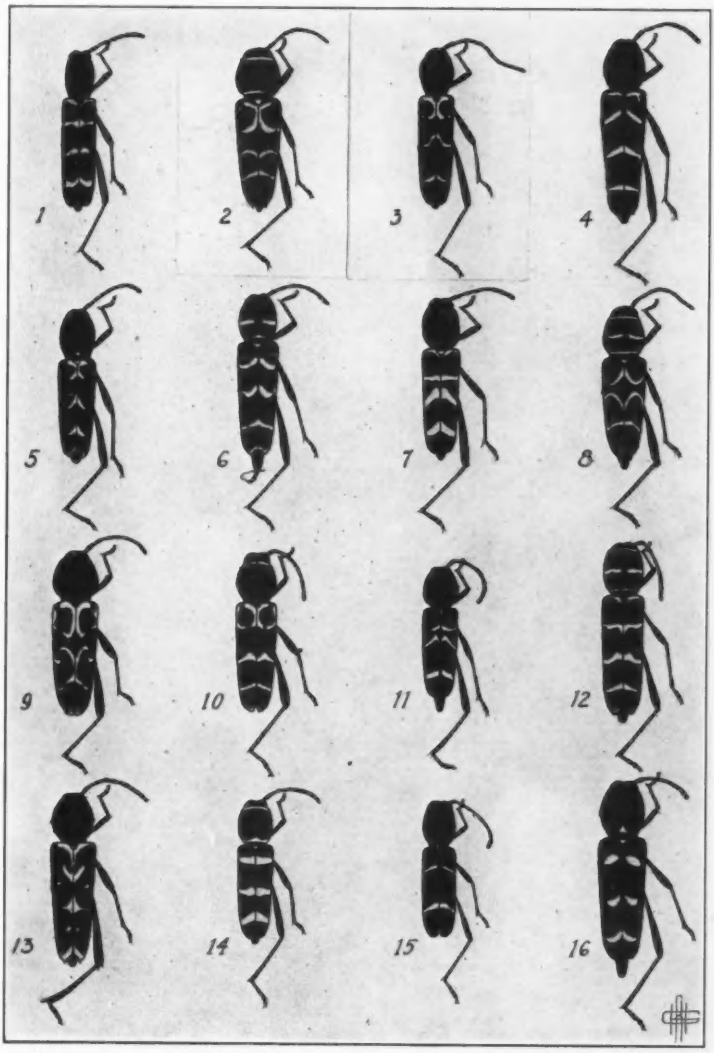
Fig.
9. *Clytus ruricola* Oliv. × 2½.
10. *Neoclytus infans* Csy. × 2½.
11. *Neoclytus approximatus* Lec. × 2½.
12. *Neoclytus irroratus* Lec. × 2.
13. *Neoclytus vanduzeei* Van D. × 3.
14. *Xylotrechus nitidus* Horn. × 3.
15. *Neoclytus abbreviatus* Schffr. × 3.
16. *Clytus blaisdelli* Van D. × 3.

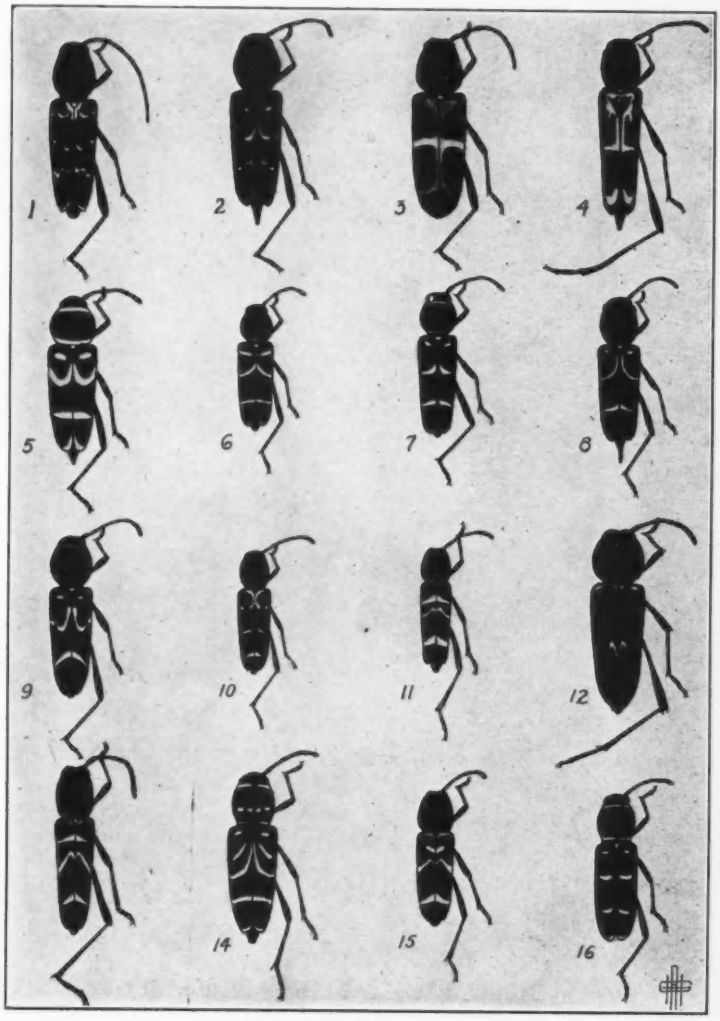
Plate V.

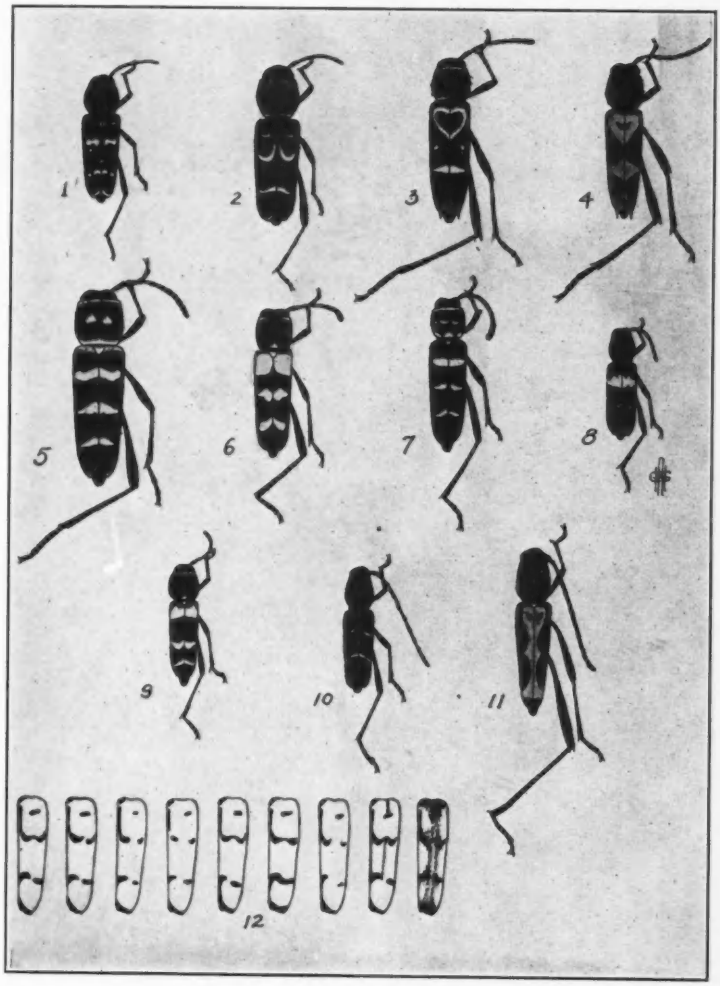
Fig.
1. *Xylotrechus mormonus* Lec. × 2.
2. *Xylotrechus schaefferi* Schott. × 3.
3. *Neoclytus longipes* ♀ Drury. × 2.
4. *Neoclytes longipes* ♂ Drury. × 2.
5. *Neoclytus magnus* Schffr. × 2.
6. *Neoclytus basillaris* Van D. × 2.

Fig.
7. *Neoclytus angelicus* Van D. × 3.
8. *Clytus clitellarius* Van D. × 2.
9. *Neoclytus provoanus* Csy. × 2.
10. *Clytoleptus albofasciatus* Cast. × 3.
11. *Euryscelis suturalis* ♂ Oliv. × 2½.
12. Variations in elytral pattern of *X. undulatus* Say.


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16


1
2
3
4
5
6
7
8
9
10
11
12
14
15
16


1
2
3
4
5
6
7
8
9
10
11
12

THE CHRYSOPIDAE (NEUROPTERA) OF CANADA.[1]

ROGER C. SMITH,
Kansas State College of Agriculture and Applied Science,
Manhattan, Kansas.

This paper is based largely upon specimens sent to the writer through the kindness of Dr. J. M. McDunnough in 1926 and in 1931 from the National Collection of Insects of the Department of Agriculture of Canada. Certain specimens of Chrysopidae were also sent for determination by Mr. W. Downes in 1926. Among them was a species which was being introduced into New Zealand at the request of Dr. R. J. Tillyard to help control certain aphid pests of shade trees. It was decided that there was one or two new species in the lot, but the writer did not wish to describe them as new until he had studied the types at the Museum of Comparative Zoology at Cambridge, Mass. This was accomplished in 1927.[2]

Most descriptions of Chrysopids are largely descriptions of color patterns or markings and venational characters. Both coloration and venation are subject to considerable variation and modification and must be interpreted in the light of these variations. There are few morphological differences which are usable. Large differences in size, length of the antennae, and size and shape of the wings have all been used and are useful recognition characters. The comparative length and breadth of the pronotum are subject to variation, depending on whether the head is extended or retracted at death. The genitalia are internal and there are few heavily chitinized parts. If cleared and mounted in balsam, it is nearly impossible to place the genitalia in positions to be able to compare corresponding parts. Lately the plan of examining genitalia

[1]Contribution No. 388 from the Department of Entomology.

[2]The writer was aided in this work by a Bache Fund grant, No. 286, to which grateful acknowledgment is hereby made. The writer wishes to express his appreciation to Professor Nathan Banks for his cooperation and assistance at that time, and for reading this paper; to Dr. J. M. McDunnough for the privilege of studying these specimens; to Mr. G. S. Walley for reading the manuscript and making corrections particularly in the spelling of names of collectors and localities, and to Mr. S. Fred Prince for the illustrations made in water colors included in this paper. The publication of these drawings in color was made possible by grant No. 325 from the Bache fund.

boiled in KOH, stained with Biebricht's scarlet and then examined in liquid has been adopted with fair results. Color patterns are still the most apparent of characteristics and the most useful if interpreted in the light of the variations and modifications which normally occur. The writer proposes to pursue a conservative attitude in species and variety making in this family. It is believed that a knowledge of the life histories and characteristics of the larvae is necessary to arrive at a satisfactory classification of the adults and for determining their relationships.

Through the kindness of Professor Nathan Banks, curator of insects in the Museum of Comparative Zoology of Harvard University, Cambridge, Mass., locality records from that collection from Canada are included in this paper.[3]

KEY TO THE GENERA OF *Chrysopidae*, INCLUDING SECTIONS OF THE GENUS *Chrysopa*, KNOWN TO OCCUR IN CANADA.

A. Median loop (M 3+4) joining the cross vein instead of M 1+2; cell 1st. M 2 equal or nearly equal to cell 1st M 4; color dark brown, with salmon or orange markings; medium size, 14 mm. or longer. (Page 582)...**Nothochrysa**

AA. Median loop joins M 1+2 enclosing a small elongate cell, 1st. M 2, which is only about one-fourth, or less, the size of cell 1st. M 4.

B. Predominantly brown or reddish brown in color, wing veins spotted with brown; gradate series of fore wings of few veins, ordinarily 3 to 5 brown veinlets only, only one series in hind wings, small in size, length, 10–14 mm. (Page 582).....**Eremochrysa**

BB. Predominantly green in color, various yellowish or reddish discolorations often occur but specimens are never as dark brown as above species; gradate series of fore wings generally of more veinlets 4–9, green or brown in color, two series in hind wings, size larger, 13–18 mm. in length.

C. Basal segments of antennae separated by as much as the width of the basal segment or more, often bowed outwardly; male with a protuberance on the front bearing a tuft of brown setae apically, female with face often sunken below the antennae. (Page 583).....**Meleoma**

CC. Basal segments of antennae not so widely separated, no protuberance on the front in the male, front not sunken below antennae, antennae not markedly bowed outwardly. (Page 584).....**Chrysopa**

D. Antennae largely black or with basal fourth blackish.

---

[3]The writer has omitted from the text the names of the collectors for the sake of brevity. The specimens seen, however, were collected by the following which are listed somewhat in the order of collections bearing their names from the most specimens to the fewest: C. B. Garrett, J. McDunnough, W. B. Anderson, H. L. Seamans, W. Downes, E. A. Rendell, D. G. Gillespie, N. Criddle, G. S. Walley, P. N. Vroom, E. H. Strickland, Kenneth M. King, N. J. Atkinson, Owen Bryant, R. D. Bird, J. J. de Gryse, E. P. Venables, A. J. Hunter, C. M. Barbeau, H. A. Robertson, R. H. Chrystal, R. C. Treherne, Arthur Gibson, G. W. Taylor, F. P. Ide, G. H. Fisk, J. A. Adams, J. W. Cockle, W. Mathers, A. W. A. Phair, E. R. Buckell, Walter Carter, W. H. Tams, L. J. Milne, A. A. Dennys, C. B. Hutchings, C. E. Petch, W. H. Danby, R. Glendenning, A. R. Graham, and K. E. Gray.

E. Basal segment of antennae without any definite black or red lines or bands, entirely greenish or yellowish in color. Mostly large species, light green, yellowish green or bluish green in color, broad wings, with gradates and generally some other cross veins black or brown. (Page 584).....Genus *Chrysopa*, **Nigricornis Section**

EE. Antennae with a longitudinal black band or line on the basal segment. Size generally smaller than above and wings with most cross veins brown in color. (Page 585),
Genus *Chrysopa*, **Lineaticornis Section**

DD. Antennae not black (except second segment) which may or may not have a black ring; generally medium to small species.

E. Antennae with a black ring on second segment or this segment entirely black. Head with elaborate black color pattern. (Page 586).....Genus *Chrysopa*, **Oculata Section**

EE. Antennae entirely light yellowish, or light brownish due to a covering of short setae, without a black second segment. Head not elaborately banded with black.

F. All veins, including gradates, entirely green; wings conspicuously long and narrow, apex acute. (Page 592),
Genus *Chrysopa*, **Plorabunda Section**

FF. Usually gradates and some other cross veins brown or black; wings broader, more rounded apically. (Page 596),
Genus *Chrysopa*, **Rufilabris Section**

The writer has decided that the genus *Cintameva* Navas is a synonym of *Chrysopa* Leach. This genus was separated from Chrysopa by Navas (Revue Russe d'Entomologie, 1914, p. 214) primarily on the basis of cross veins in the stigmal region. The description states (transl), "Stigmal region of the wing with many distinct veins, space behind the stigma in the subcostal area with many apical veins * * *. The special form of the stigmal region in the two species *comitissa* and *venulosa*, very different from what one finds among the other species of *Chrysopa* gives us authority to separate them into a section." *C. venulosa* was designated as the type but later Navas placed the following American species and varieties of Chrysopa in this genus: *chi upsilon*, *chlorophana* and *oculata*.

The criticism of the genus offered by Lacroix (Réflections sur le genre *Cintameva* Navas. Compt. Rend. Assoc. Franc. Avanc. Sci. 49:436–438; 1925 (1926) in which the author pointed out the diversity of the group of species Navas has placed in the genus appears to the writer as a valid one. Furthermore, having followed the venation from the pupal tracheation to the adult, the writer is not disposed to take numbers and arrangements of minor veins in Chrysopid wings too seriously. Most anything can and does happen. Then, too, *Chrysopa perla* Linn. is usually regarded as the type of the genus Chrysopa and was so designated by Banks (1903) so the species cannot be removed from the genus, as was done by Navas, (1915, p. 10).

Genus **Nothochrysa** McLach.

McLachlan, Trans. Ent. Soc. Lond., 1868, p. 195.
(Genotype, *Nothocrysa fulviceps* McLach.)

1. **Nothochrysa californica** Banks.

(Plate I, Fig. 5.)

Banks, Trans. Amer. Ent. Soc., XIX, 1892, p. 373.

Only a single specimen of this handsome species has been seen from Canada (Fig. 5). It was collected by W. B. Anderson, Victoria, B. C., May 4, 1918. The specimen was badly damaged by museum pests and has been mounted on a slide. It was compared with Banks' type in the Museum of Comparative Zoology. The head appears small. It is broad across the compound eyes and relatively short vertically. The labral region is conspicuously narrow. There is a series of black loop-like bands on the front, the antennal bases are surrounded with a black band and there is a median black band on the vertex. The color of the head is salmon. The antennae are black, including the basal segment.

The wing veins are wholly reddish brown. The base of C and of R is bright yellow in the front wing. The stigma is reddish brown above Sc, and the wing membrane is yellowish between Sc and R. The outer series of gradates has seven red-brown veins, the inner has six.

Genus **Eremochrysa** Banks.

Banks, Trans. Amer. Ent. Soc., XXIX, 1903, p. 158.
(Genotype, *Chrysopa punctinervis* McLach.)

KEY TO THE SPECIES OF EREMOCHRYSA KNOWN TO OCCUR IN CANADA.

A. Many cross veins in front wings wholly brown or blackish, not interrupted with light spots, or with veins but very faintly spotted.....**fraterna**
AA. Practically all veins, including the cross veins, brown, interrupted with light spots; venation lighter than in the above species.....**punctinervis**

2. **Eremochrysa fraterna** (Banks).

Banks, Proc. Ent. Soc. Wash. IV, 1898, p. 174.

Two specimens collected at Seton Lake, Lillooet, B. C., May 28–29, 1926 by J. McDunnough, are in the Canadian National Collection at Ottawa. The specimens are undersized, being only 9 and 9.5 mm. from head to tip of folded wings.

3. **Eremochrysa punctinervis** (McLach.).

Chrysopa punctinervis McLachlan, Ent. Month. Mag. VI, 1869, p. 24.

A single specimen collected by C. B. Garrett at Oliver, B. C., May 23, 1923, is in the Canadian National Collection.

Genus **Meleoma** Fitch.

Fitch, First Rept. Ins. New York, 1856, pp. 81–82.
(Genotype, *Meleoma signoretti* Fitch.)

KEY TO THE SPECIES OF MELEOMA OF CANADA.

A. No black or dark-brown band on the genae below the eyes. Antennae brownish or basal portion very dark, appearing blackish, palpi wholly yellowish green; horn of male as long as width of vertex.....**signoretti**
AA. With black or dark-brown genal bands, antennae yellowish or greenish, palpi marked with black; horn of male very short.
B. Third antennal segment much longer than the second—about five times longer; palpi lined with reddish black on outside, wing veins wholly green in apical third of wing, cross veins near base brownish....**verticalis**
BB. Third segment of antennae not over twice as long as second, sometimes not longer than second, palpi broadly banded longitudinally on outside with black or wholly black; gradate veinlets brown.....**emuncta**

4. **Meleoma emuncta** (Fitch).

Chrysopa emuncta (Fitch), First Report Ins. New York, 1856, p. 88.
Meleoma slossonae Banks, Ent. News, VII, 1896, p. 95.

Twenty specimens of this species are in the Canadian collection. The localities indicated on the labels are Departure Bay, Lillooet and St. Marys, B. C.; Knowlton, Hemmingford, Kazubazua, Covey Hill, and Aylmer, Quebec; Rostrevor, Ontario, and three specimens without localities indicated. Banks considers *M. slossonae* Banks a synonym. This species has been previously reported from Quebec and Sherbrooke (Banks, 1903).

There is a female specimen in the Canadian collection, collected by J. McDunnough at Seton Lake, B. C., May 28, 1926, which may be a new variety of *emuncta*. It has the general characters of *emuncta*, but the pronotum is margined by two broad, brown bands similar to *gravida*. There is an extra black mark from the base of the antennae along the lateral borders of the clypeus. Total length 14 mm.

5. **Meleoma verticalis** Banks.

Banks, Trans. Amer. Ent. Soc. XXXIV, 1908, p. 259.

A single male specimen of this species from Canada occurs in the Canadian National Collection. It was taken by F. P. Ide at Joe Lake, Algonquin Park, Ontario, July 11, 1928.

It can be identified by the very long third antennal segment. The horn which is short like that of *emuncta* is three pointed. There is a tuft of white hair on the front below it.

6. **Meleoma signoretti** Fitch.

Fitch, First Rept. Ins. New York, 1856, p. 82.

Two specimens of this species, both females, occur in the Canadian collection, one each from Knowlton, Quebec, and Oliver, B. C.[4]

Genus **Chrysopa** Leach.

Leach, Edinb. Encycl. IX, 1815, p. 138.

1. THE NIGRICORNIS SECTION OF CHRYSOPA.

KEY TO THE SPECIES OF THE NIGRICORNIS SECTION OF CHRYSOPA.

A. Palpi heavily banded with black or at least one segment wholly black; a reddish or blackish band occurs in some species along each side of the pronotum.
  B. Pronotum broadly margined with a shining brownish-black band; a shining black band on the genae, and loops under each antennae on the front of which extend, though broken at the vertex along the margins of the compound eyes, to the thorax.....**coloradensis**
  BB. Pronotum not margined with a definite, blackish band. Facial marks not as above, but a shining black band entirely around each antennal socket.....**excepta**
AA. Palpi entirely yellowish or greenish-yellow, not banded with black; no lateral bands or pronotum.
  B. A black spot each side on the clypeus, sometimes a second pair each side on the labrum, upper part of second segment black; basal part yellowish, cross veins between R1 and Rs green or partly black, large species.....**nigricornis**
  BB. Face without any black spots on genae, wholly greenish or yellowish, entire second segment of antennae yellowish, cross veins between R1 and Rs usually wholly black, small species.....**columbiana**

7. **Chrysopa nigricornis** Burm.

Burmeister, Handbuch Ent. II, 1839, p. 980.

This is probably a fairly common species in Canada. Seventeen specimens have been seen. They were taken at Victoria, Osoyoos, Oliver, Vancouver, and Vernon, B. C.; Lethbridge, Alta.; West Ottawa and Orillia, Ont.; Hemmingford, Quebec. The specimens are large but do not differ from the typical forms.

---

[4]After this paper had been submitted for publication, a small collection of Chrysopids was determined for Mr. Wm. L. Putman, St. Davids, Ontario. The following species, collected August and September, 1931, from St. Davids and Niagara, Ontario, were contained in it: *Meleoma signoretti*, *M. emuncta*, *Chrysopa lineaticornis*, *C. downesi*, *C. nigricornis*, *C. quadripunctata*, *C. plorabunda*, *C. rufilabris*, and the *oculata*, *illepida* and *albicornis* varieties of *C. oculata*.

8. **Chrysopa coloradensis** Banks.
(Plate I, Fig. 6.)

Banks, Trans. Amer. Ent. Soc. XXII, 1895, pp. 314–315.

This handsome species, readily recognized by the facial and pronotal color markings (Fig. 6), is a fairly abundant species in Canada. Twenty-two specimens have been seen by the writer. The localities were Seton Lake, Salmon Arm, Creston, Oliver, Keremeos and Penticton, all from British Columbia. The specimens were collected from May to August, inclusive. The writer has specimens from the states of Washington and Idaho, so the range of this species appears to extend from Colorado northwesterly.

9. **Chrysopa columbiana** Banks.

Banks, Trans. Amer. Ent. Soc. XXIX, 1903, p. 150.

A single specimen was seen from Canada. It was collected by C. B. Garrett at Oliver, B. C., August 7, 1923.

10. **Chrysopa excepta** Banks.

Banks, Trans. Amer. Ent. Soc. XXXVII, 1911, p. 340.

Three specimens of this strikingly marked species has been seen from Canada. The localities are Nicola and Oliver, B. C., and Lethbridge, Alta. The specimens were taken in May (2) and June.

2. THE LINEATICORNIS SECTION OF CHRYSOPA.

11. **Chrysopa lineaticornis** Fitch.

Fitch, First Rept. Ins. New York, 1856, p. 91.

This is the only representative of this group in Canada and only one specimen of this species from Canada has been seen by the writer. It is from Aylmer, Quebec, and was collected by G. S. Walley, August 3, 1927. The larva is a trash carrier.

This species may be recognized by the black, longitudinal line on the upper side of the basal segments of the antennae, basal fourth of the antennae black, fading off to brownish, palpi and genae without marks and wings with most all cross veins brown in color.

3. THE OCULATA SECTION OF CHRYSOPA.

KEY TO THE SPECIES OF THE OCULATA SECTION OF CHRYSOPA.

A. All wing veins, including the gradates in both wings, entirely green, wings broad, rounded at tips (specimens with only a little black at the ends of the costals in the hind wings may be placed here). (Page 587), **oculata** var. **chlorophana**

AA. Some cross veins in the wings wholly or at least in part dark; gradates generally dark.

B. Pleural sutures outlined with black, a black line along the compound eyes above the antennae, spots on the vertex fused into two longitudinal dark bands, a black transverse band across the occiput, wings very hairy. (Page 591) ..... **pleuralis**

BB. Pleural sutures not outlined with black, no black transverse line across the occiput.

C. Face with Y-shaped mark between antennae which may or may not be connected with spots below the antennae if present. With black band from eye to mouth or genae.

D. Face brownish gray. Without prominent black spots on vertex and front. Wings with practically all cross veins brown, a brown clouding in the membrane along these veins. (Page 591) .. **canadensis**

DD. Face yellowish in color, heavily marked with shining black spots on the front, clypeus and vertex. Prothorax with two or three pairs of large, black spots. No brown clouds in the wing membrane near cross veins. (The Chi group).

E. Mark between the antennae disconnected from the spots below the antennae but connected or not to the spots on the vertex so that a Y-shaped mark results. (Page 592) ..... **chi** var. **upsilon**

EE. Mark between the antennae connected to the subantennal spots, may or may not be connected to these on vertex, so that an X is formed. (Page 592) ..... **chi**

CC. No X- or Y-shaped black mark between the antennae, the broad, black band between the antennae stops short of the vertex.

D. Black loops under the antennal sockets not connected to the band or spot under the eyes on the genae, or the connection is very faint. (Page 590) ..... **oculata** var. **separata**

DD. Genal and clypeal bands connected as occurs normally.

E. Vertex uniformly yellow without separate spots or the spots forming two short, elongated spots generally connected with the black band above the antennae.

F. Vertex without any brown or black spots, or there are small spots in the reddish band above the antennae.

G. No spots at all on the vertex. (Page 588) ... **oculata** var. **carei**

GG. Small, black or brown spots in or closely connected with the band above antennae. (Page 589) .... **oculata** var. **xanthocephala**

FF. Vertex with two separate brown spots or two short bands.

G. Vertex with only two small brown spots, not connected with the band above the antennae. (Page 589) . **oculata** var. **bipunctata**

FFF. Vertex with the two or four spots normally occurring on the vertex fused into two elongate spots or short bands usually connected in front with the reddish band above the antennae. (Page 590) ..... **oculata** var. **illepida**

EE. Vertex with four separate, brownish spots and usually another behind each compound eye; pronotum with two to four pairs of black spots; wings with medium to very dark venation.

F. Usually small individuals with most cross veins brown or black; the darkest winged members of this group. (Page 590), **oculata** var. **albicornis**

FF. Larger specimens with only medium dark venation. Costals black only at ends. Prothorax with three or four pairs of brownish or black spots. (Page 587) ..... **oculata** var. **oculata**

12. **Chrysopa oculata** Say var. **oculata** Say.
(Plate I, Fig. 4.)

Say, Jour. Acad. Sci. Phila. VIII, 1839, p. 45.

This is the most common species of Chrysopid in Canada. Many specimens of this species occur in the Canadian Museum. The Canadian localities indicated are Salmon Arm, Oliver, Wellington, Victoria, Vernon, B. C.; Lethbridge, Iron Springs, Banff, Alta.; Hemmingford, Queen's Park, Covey Hill, Quebec; Saskatoon, Sask.; Aweme, Man.; Pt. Pelee, Aylmer, St. Thomas, Algonquin Park, Sand Lake, Chatham, Lyn, and Ottawa, Ont.; Kentville, N. S.

This species is very variable as to color pattern and degree of darkness of wing veins. The author thinks there is sufficient need for referring to various forms or varieties to justify recognition of the following forms or varieties which are chiefly species synonyms. Certain of the European forms have large numbers of varieties, *vulgaris* having more than 30 described colorational and venational variations.

The typical form includes those specimens with the gradates partly or wholly black in color, the genal marks complete; with four spots (or two spots and two short bands from the antennal band) on the vertex and with several pairs of black spots on the pronotum (Fig. 4).

Navas, (Ent. Zeitsch. 1913, 27, p. 20) has described *Chrysopa rubicunda* from the United States for a form in which the head is entirely red. There were perhaps a half dozen specimens of *C. oculata* in the Canadian collection conforming to this description. This reddening is thought by the writer to be due to allowing the specimens to remain too long in a strong cyanide killing bottle and to be entirely secondary. It occurs on all varieties of *oculata*, on *rufilabris* and *plorabunda*. No living forms with heads entirely red have ever been seen by the writer except in overwintering adults of *plorabunda*. The writer does not regard this as a valid species nor even a variety worthy of recognition.

13. **Chrysopa oculata** var. **chlorophana** Burm.

Chrysopa chlorophana Burmeister. Handb. Ent. II, 1839, p. 979.

This variety is distinguished by the wholly green wing venation. All cross veins except the costals of the hind wings are green. The head markings are variable and include the

variations described for the other varieties. The wings tend to be broad and the specimens are predominately females. This variety is fairly common in Canada. Specimens have been seen from Lethbridge, Waterton, and Iron Springs, Alta; Oliver and Vernon, B. C.; Saskatoon and Indian Head, Sask., and Aweme, Man.

14. **Chrysopa oculata** var. **carei** n. var.

This variety is characterized by the complete absence of any brown spots on the vertex. The blackish spots on the post genae or back of the compound eyes are generally present. The vertex is very yellow. The genal spots in the type are disconnected from the antennal band as occurs in *separata*, but in most of the paratypes it is connected as in the other varieties. The facial antennal and palpal markings are as in the typical variety of *C. oculata*.

The markings on the pronotum vary. In the type, the pronotum is irregularly blotched with blackish. In paratypes there is a variation to the practically complete absence of black spotting.

The wings are predominately green veined. The gradates of the type are green. The costals and those between R1 and Rs are black at the ends. The paratypes tend toward the absence of dark veins.

The chief excuse for indicating this colorational form as a variety is to indicate that this is not a distinct species, but a striking form attained by the gradual disappearance of vertical markings. This tendency begins with *pleuralis*, the form with the most heavily marked vertex. It proceeds to *oculata* through the varieties *oculata*, *illepida*, *bipunctata* to *carei*, where the vertex is without spots. Measurements are as for *oculata*, 15 mm. to 19 mm. in length.

The species name is from the latin *careo*—to be lacking. Ten specimens occur in the Canadian collection. The type is from Cranbrook, B. C., collected by A. A. Dennys, June 6, 1926. Other localities are Pouce Coupe, Rolla, and Creston, B. C.; Kentville, N. S.; St. Thomas, Ont.; Aylmer, Quebec, and Lethbridge, Alta.

One specimen from Creston, B. C. is a remarkable venational freak. The lower branch of media, m 3+4 joins the crossvein at the end of the cell in the manner of *nothochrysa* in both

front wings. This venational characteristic, together with a rather striking head pattern, suggested at first a new genus and species, but a larger collection containing a number of forms with the same head pattern indicates to the writer that this is a freak specimen only. It is not uncommon to find this variation in one wing of Chrysopa only, but to find it so perfect in both wings is rare.

Lacroix (Bul. Ent. France, 1915, p. 244) has designated a similar abnormality in *Chrysopa perla* as ab. *nothochrysiformis*. Where this abnormality occurs in both wings, designating the aberration in this manner appears to the writer to be a useful and concise designation. However, the aberration so often occurs in only one of the front wings. The form designation would then be of doubtful usefulness.

15. **C. oculata** var. **xanthocephala** Fitch.

Chrysopa xanthocephala Fitch, First Rept. Ins. New York, 1856, p. 85.
Not *C. xanthocephala* Navas. Bul. Soc. Ent. Suisse, Vol. 12, 370, 1916, from Tunis.

This variety is being retained for those specimens of *C. oculata* in which there are two spots on the vertex, but the spots are either in the reddish bands above the antennae or are connected closely with them.

These spots may be very small and extend very little above the band, or they may be longer, forming two little, elongate brownish spots on the vertex. One finds a regular gradation of fusion of these spots from *carei* to *illepida*. This is merely an intermediate step.

The head is predominately yellow. The Fitch type has considerable red on it, however. The Canadian specimens all lack red on the vertex, but the replacement of yellow with red or brown is common in the Chrysopids.

Twenty-three specimens were seen from Canada. The localities are Ottawa, Cornwall, Kearney, Strathroy, Ontario; Kentville, N. S.; Covey Hill, Kazubazua, Aylmer, Ottawa Club, Quebec; Rolla, Comox, Salmon Arm, B. C.; Iron Springs, Alta.

16. **C. oculata** var. **bipunctata** Fitch.

Chrysopa bipunctata Fitch. First Rept. Ins. New York, 1856, p. 87.

This varietal name may be retained for those specimens of *C. oculata* with two disconnected brown spots on the vertex.

The spots are not connected with the band above the antennae. These spots are usually more or less circular, some shade of brown or black in color and lie some distance up on the vertex.

Seven specimens in the Canadian collection may be so classified. The localities are Black Rapids, Rideau, Algonquin Park, Ont.; Kentville, N. S.; Iron Springs, Alta; Rolla and Nelson, B. C.

17. **C. oculata** var. **illepida** Fitch.

Chrysopa illepida Fitch. First Rept. Ins. New York, 1856, p. 84.

This synonym may be retained to indicate a colorational form between *xanthocephala* and *bipunctata*. The spots on the vertex are fused into two prominent broad brownish or blackish bands which are usually connected with the antennal band in front (Fitch. 1856, p. 84).

Five specimens in the Canadian collection may be so classified. The localities are Salmon Arm, Vernon, B. C.; Hemmingford, Seven Isles, Quebec; and Ottawa, Ontario.

18. **Chrysopa oculata** var. **albicornis** Fitch.

Chrysopa albicornis Fitch. First Rept. Ins. New York, 1856, p. 84.

This variety has the darkest venation of this species, and the specimens are predominately males. The specimens are generally smaller than the typical form. The vertex usually has two pairs of black dots and the pronotum usually has several pairs as described for *oculata*. It is somewhat more prevalent in the northern part of the United States and is probably fairly plentiful in Canada. Specimens from Oliver and Vernon, B. C.; Covey Hill, Aylmer, Hemmingford and Knowlton, Quebec have been seen. *Chrysopa assimilis* Banks is, in the writer's opinion, a synonym of this species and variety.

19. **Chrysopa oculata** var. **separata** Banks.

Chrysopa separata Banks. Trans. Amer. Ent. Soc. XXXVII, 1911, p. 341.

This variety is distinguished by the absence of a connection between the black loop under the antennae and the black genal band. Ordinarily there is a black band extending between them. This undergoes various stages of reduction in width to its complete absence. The writer places under this variety specimens where the connecting band is reduced to almost a hair line, or where the band is narrow and interrupted.

This variety is not plentiful either in the United States or Canada. Seven Canadian specimens have been seen from Agassiz, Nelson, Rolla, and Salmon Arm, B. C.; Hull and Knowlton, Quebec.

20. **Chrysopa pleuralis** Banks.

(Plate I, Fig. 2.)

Banks, Trans. Amer. Ent. Soc. XXXVII, 1911, p. 341.

Ten specimens of this strikingly marked, very dark, very hairy species as originally described from Colorado occur in the Canadian National Collection. The Canadian specimens may represent a variety of this species because of the longer hair on both sides of the wing veins than the type shows and because of the prominent red markings on the head. There is a prominent triangular, bright red spot between the black bands just above the bases of the antennae (Fig. 2), and the black bands on the front are bordered along the lower margin with bright red. There is a bright red band next to the compound eyes also on the Canadian specimens. These red markings do not occur on the type in the Museum of Comparative Zoology. But since specimens of *C. oculata* vary in the amount of red on the front and vertex, the red markings on this species are probably a normal variation. The heavy black markings on the head are the same, the black lines outlining the pleural sutures and the long very conspicuous spines are approximately the same as occurs on the type. This is a small, very strikingly marked species, and there is little variation in the Canadian specimens. The localities are Waterton, Banff, and Waterton Lakes, Alta.; Merritt and Hedley, B. C.

21. **Chrysopa canadensis** Banks.

Banks, Trans. Amer. Ent. Soc. XXXVII, 1911, p. 339.

The type is the only specimen of this species in the Museum of Comparative Zoology. It is from Go Home Bay, Ontario. It is similar to *Chrysopa chi* Fitch, but can be recognized by the antennae being longer than the body, the head is reddish or pinkish over brownish, with a small black Y between the antennae; there are prominent brownish black spots on the dorsum of the pronotum; nearly all cross veins are brown and there are brown cloudings in the membrane adjacent. The writer believes this is a valid species. No specimens of this species were discovered in the Canadian collection.

22. **Chrysopa chi** var. **chi** Fitch.

Chrysopa chi Fitch, First Rept. Ins. New York, 1856, p. 87.

This species is probably as plentiful in Southeast Canada as in the northeastern part of the United States. Twenty-four specimens are in the Canadian collection from Edmonton and Lethbridge, Alta.; Hazelton, Rolla, Agassiz, Vancouver Island, Vernon, and Sicamous B. C.; Teulon and Aweme, Man.; Covey Hill, Aylmer, Knowlton, Cascade, Kazubazua, Quebec; Kentville, N. S., and Saskatoon, Sask. Specimens are in the Museum of Comparative Zoology from Nepigon, Ont. and Vancouver, B. C.

23. **Chrysopa chi** var. **upsilon** Fitch.

Chrysopa upsilon Fitch, First Rept. Ins. New York, 1856, p. 87.

Thirteen specimens of this variety occur in the Canadian collection. The localities are Fredericton, N. B.; Blacksburg, Burkes Falls, Britannia, Sand Lake, and Ottawa, Ont.; Knowlton, Quebec; and Agassiz, B. C. This is a mere colorational variety of ***chi*** as shown by Smith (1922, p. 354).

Specimens from Canada are in the Museum of Comparative Zoology, from Treesbank and Winnipeg, Man., and Vancouver, B. C.

Navas (Neuropteros Nuevas o poco Conocidos. Mem. de la Real Acad. de Cienc. Y Artes de Barcelona, 1918, vol. 14, 354–355) described a variety of ***upsilon*** (the author spelled it hypsilon), designating it ***haematica***, from White Plains, N. Y. The form is described as having a brown head and with red on each side of the labrum (probably clypeus, as the labrum is very small). This is undoubtedly a specimen discolored by age or from the action of hydrocyanic acid upon the pale-green coloring of the head. The writer sees no occasion for varietal designation of such discolored specimens.

4. THE FLORABUNDA SECTION OF CHRYSOPA.

This group contains several very perplexing, variable species. They are separated mainly on colorational characteristics. No satisfactory morphological characters which can be used as species criteria have yet been discovered. The leaf-green coloration changes to shades of yellow and brown during the fall and winter, so that late fall and early spring specimens are generally light yellowish in color, heavily blotched

with reddish or light brown (Banks, 1915) (Smith 1922, p. 1336). So far as known, most, if not all of the representatives of this group pass the winter as adults.

The writer proposes to recognize several synonyms as varieties, mainly as aids in showing the relationship of the variants and as aids to identification.

KEY TO THE PLORABUNDA SECTION OF CHRYSOPA.

A. Genae with a narrow definite black or very dark red band from the eye to the mouth; with or without slight reddish suffusion on the median border of this line, dorsal ivory or yellowish band always prominent.
  B. Small, very dark green specimens, known from northwestern United States and western Canada, often with an oily appearance in pinned material, ivory band very prominent over pronotum and generally so to tip of abdomen. Head generally greenish yellow, sides of pronotum often suffused with black. (Page 594) ..... **downesi**
  BB. Larger specimens, medium green, generally without an oily appearance.
    C. A narrow black band from eye to the mouth over the genae and with only a little red adjacent to it. North-central United States and Southern Canada. (Page 593) ..... **plorabunda**
    CC. With the black or dark-red band ordinarily present, but with extensive reddish suffusion, reaching well over the genae and sides of clypeus. (Page 594) ..... **plorabunda** var. **californica**
AA. Genae lacking a narrow definite black or dark-red band from eye to mouth, but a reddish suffusion occurs generally with an indefinite median border. Dorsal ivory band present, but less prominent ordinarily.
  B. Body coloration a deep green, but not dark green in color, head yellow, ivory stripe fairly prominent, particularly over the pronotum, wings long and narrow; M 3+4 usually ends at or beyond the cross veinlet; known to occur in Northeast United States and South Canada. (Page 595) ..... **harrisii**
  BB. Genal band a more extensive suffusion of red, without definite median border on clypeus. Face ordinarily very red, M 3+4 fuses at or before the cross veinlet above; very light green or yellowish green. Western specimens. (Page 596) ..... **harrisii** var. **externa**

24. **Chrysopa plorabunda** Fitch.

(Plate I, Fig. 1.)

Fitch, First Rept. Ins. New York, 1856, p. 88.

This species may be recognized by the narrow black band from the eyes to the mouth and bordered on the inner margins by only a small amount of light red (Fig. 1). The genae are not heavily suffused with red. This black line is very constant. In northern specimens it is broader and the red along the inner margin is more extensive.

Forty-seven specimens from the Canadian National Collection have been seen by the writer. The localities are Lethbridge, Calgary, Alta.; Ft. Qu'Appelle, and Saskatoon, Sask.; Salmon Arm, Oliver, Keremeos, Victoria, Vancouver, St. Marys, Kaslo, Agassiz, Creston, and Vernon, B. C., and Aweme, Man.

Sixteen other specimens, most being from the United States, show the characteristic late fall and winter discoloration.

25. **Chrysopa plorabunda** var. **californica** Coq.

Chrysopa californica Coquillett, Rept. Calif. State Bd. Hort., 1890, p. 288.

This species is here for the first time recorded as a synonym, but the writer believes there are reasons for retaining the name as a variety. This variety has the narrow black genal band characteristic of this species, as mentioned in Coquillett's description but with prominent reddish suffusion on the genae and sides of the clypeus adjacent to the line. The median border of the red area is sometimes clean cut, but it is generally indefinite. This is the most common form in western United States and also occurs in Southwestern Canada. Specimens have been seen from Wellington, Oliver and Seton Lake, B. C.; Lethbridge, Alta.. and Saskatoon, Sask.

26. **Chrysopa downesi** n. sp.

(Plate I, Fig. 3.)

A small variable species, very dark green in color, with sharply defined ivory dorsal band, narrow wings with green stigmas and wholly green venation (Fig. 3); face marked like *plorabunda* but ordinarily with more reddish suffusion and a general oily appearance throughout.

Head grayish below the antennae and with the vertex yellowish green. A narrow black band over the genae similar to *plorabunda*, but more caudal in position; genae and clypeus heavily suffused with reddish at each side. Palpi brown, without appearance of bands, vertex uniformly yellowish green. Basal segment of antennae yellow, rest of antennae uniformly light yellowish-green, ending in a pointed brownish segment; length about two-thirds that of the folded wings.

Pronotum about as broad as long, sides slightly convergent, dark yellowish-green in color, a definite, clear-cut, median narrow light yellow band, the dark green borders prominently suffused with black. Rest of thorax and abdomen dark green in color with the light yellow band extending all the way, being particularly prominent on the mesothorax and anterior segments of the abdomen, body sparsely beset with short and inconspicuous decumbent white hairs with a few black ones on the sides of the pronotum. Venter of the thorax light green and of the abdomen yellowish. Legs wholly yellowish green; tarsi amber.

Wings conspicuously narrow with angular tips. Venation wholly green, stigmas yellowish green, fairly conspicuous. Gradates of both wings 6 (outer) and 5 wholly green; 11 veins between R1 and Rs, the distal two close together. Median loop ends before the cross vein. Veins sparsely beset with the usual black setae, mostly on the upper side of the veins, very sparse on lower side.

Total length, 13.5 mm. Length of front wing, 11 mm., width, 3.5 mm.

Holotype, a female, collected by W. Downes, after whom the species is named, at Kelowna, B. C. In the Canadian National Collection, Ottawa.

A large series of paratypes, 42 in number, from Vernon, Salmon Arm, Lillooet, Kelowny, Rock Creek, Victoria and Keremeos, B. C., and two specimens from Saskatoon, Sask. This species shows considerable variation but they are so gradated that the indication of varieties or forms appears inadvisable. The specimens vary in length from 12 to 16 mm. Some specimens have scarcely any genal and clypeal marks, others have the clypeus very red, most specimens do not have as much black on the sides of the pronotum as the type. The median light band is less distinct in some specimens. In all, the wing veins are entirely green. Some have slightly broader wings. The oily appearance of the specimens varies from a marked shining oiliness to its almost complete absence.

This is the species which the Canadian Department of Entomology introduced into New Zealand at the request of Doctor Tillyard. Mr. Downes informed the writer, by correspondence, that this species overwintered as adults under the loose bark of pine trees.

27. **Chrysopa harrisii** Fitch

Fitch, First Rept. Ins. New York, 1856, p. 90.

This is another variable species whose limits of variation are difficult to define. The writer classifies under this name narrow, wholly green-winged species with prominent light yellow dorsal band; genae without any narrow, posterior black band but with a broad reddish band.

Five specimens from Canada have been seen. The localities are Victoria and Comox, B. C., and Ontario. Several cocoons are pinned with the adults. They are yellowish-green in color.

Three other specimens without locality labels have been placed under this species, but they show considerable variation from normal. The wings are very long, narrow, and angulate and the setae on the wings are longer than occurs on this species typically. The palpi have a broad, black, longitudinal line on the outside and the rest of the segments are brown. The palpi are, therefore, darker and more marked than is typical. The genal band is uniformly dark red, very broad, covering the sides of the clypeus and has a definite median border like *rufilabris*. There are large, bright red spots near the compound

eyes on the vertex. The sides of the pronotum are conspicuously blackish.

28. **Chrysopa harrisii** var. **externa** Hagen.

Chrysopa externa Hagen, Syn. Neur. N. Amer., 1861, p. 221.

The name *externa* is here recorded for the first time as a synonym. It may well be retained as a variety of *harrisii* for those specimens, chiefly western, where the genae and clypeus are heavily diffused with red. There is no black bar or band at the hind border of the red area. The divisory veinlet (M 3+4) usually ends at or before the cross vein. These specimens are very light green or yellowish-green and are often much faded.

Eight specimens have been seen from Canada. The localities are Vancouver, Keremeos, Oliver, B. C.; Saskatoon, Sask.; and Midnapore, Alta.

5. THE RUFILABRIS SECTION OF CHRYSOPA.

This is a somewhat heterogenous group of species probably not very closely related to each other. *Rufilabris* is the most common one given here and *quadripunctata* next, but all are uncommon in Canada. All but the two mentioned species are rare in the United States.

KEY TO THE SPECIES OF THE RUFILABRIS SECTION OF CHRYSOPA.

A. At least two pairs of orange spots on the pronotum, often a pair on the vertex near the eyes and orange spotting on the mesonotum and sides of abdominal segments, a dark-red band on each gena, a small, delicate yellowish-green, tree or bush species.....**quadripunctata**

AA. No definite yellow or orange spots on the pronotum, the head or abdomen.

B. No bands of any color on the genae or clypeus, head without definite markings. (Page 598).....**intacta**

BB. Some definite head markings in the form of bands on the genae, clypeus or front.

C. Face with a broad black transverse band below antennae with black loops broadly encircling the bases of the antennae; broad reddish-brown or brownish-black bands along the margins of the pronotum and extending posteriorly only slightly less conspicuously.....**gravida**

CC. No such bands on the face and no broad brownish bands on sides of pronotum and the rest of the body.

D. Band over the genae under the eye broad and some shade of bright red, with the median borders definite; median, light yellow dorsal band particularly over the pronotum.....**rufilabris**

DD. Band over the genae black or brownish black; no light yellow dorsal band over the pronotum.

E. A brownish-black band over both the genae and clypeus; palpi broadly banded with black; brown veins ordinarily with brown clouding in the membrane adjacent, smaller species 13–15 mm. **cockerelli**

EE. A black bar each side of the clypeus; genae ordinarily without black band, palpi often brownish but not black. Large species 18–21 mm.....**majuscula**

29. **Chrysopa quadripunctata** Burm.

Burmeister, Handb. Ent. II, 1839, p. 980.

Only two specimens from Canada occurred in the collections. The locality was Vancouver Island. Two others from Chicago, Illinois occur in the collection. These specimens were large but the colorational features were normal.

30. **Chrysopa gravida** Banks.

Banks, Trans. Amer. Ent. Soc. XXXVII, 1911, p. 343.

This large, exceptionally beautiful species appears to be very rare everywhere. Only three specimens from Canada have been seen. The localities are Departure Bay, Victoria, and Vancouver Island, B. C. Two specimens are normal as to size, being 20 and 21 mm. long, but the third is very small, measuring only 16 mm. long.

31. **Chrysopa rufilabris** Burm.

Burmeister, Handb. Ent. II, 1839, p. 979.

Four specimens, three from Vineland, Ont., and one from Ottawa in the Canadian National Collection. The coloration is a little more intense than in specimens from Eastern United States. The heads are very yellow, the genal bands are very broad and light red in color. The wings appear to have a few more brown cross veins also than usually occurs.

32. **Chrysopa majuscula** Banks.

Chrysopa erythrocephala Banks, Trans. Amer. Ent. Soc. XXX, 1899, p. 201.
Chrysopa majuscula Banks, Psyche XIII, 1906, p. 98.

An exceptionally large and very uncommon species, resembling *nigricornis*, but with antennae yellowish-green throughout. Only one specimen from Canada occurs in the Canadian collection. It was collected July 1908, at Departure Bay.

This species was originally described by Banks as *erythrocephala*, but the name not being available, the species was changed to *majuscula* (Banks, Psyche, 1906, p. 98).

33. **Chrysopa cockerelli** Banks.

Banks, Trans. Amer. Ent. Soc. XXIX, 1903, p. 154.

This mid-western species with trash-carrying larva appears to be uncommon in Canada. Only one specimen from Canada has been seen. It was collected at Victoria, B. C.

34. **Chrysopa intacta** Navas.

Navas, Broteria X: 199, 1912.

This type is from Toronto, Canada. Since the description is in a journal not available to most entomologists the writer is including his translation of the original description herewith. (Navas: Broteria. X: 199, 1912.)

(9) *Chrysopa intacta* sp. nov.

Greenish yellow. Head without marks; palpi scarcely dark; eyes when dry (in death) pale brownish; first segment of the antenna elongate. Prothorax longer than broad, anterior angles truncate, impunctate; meso- and metanotum with middle area yellow. Abdomen not punctate. Tarsi of legs not at all dark. Wings hyaline, iridescent, stigma greenish-yellow, cross veins more yellow. Some of the costal veinlets of anterior wings or the bases near sub-costa, radial and those next to radius, gradates 7/9, first intermedia, first and last procubitals, cubitals, all posterior marginal cross-veins, nearly wholly black. Procubital cell typically oval, distal end extends to first intermediary vein. Costal veins of posterior wings near black at bases, gradate veinlets 3/9.

Length front wing, 16 mm.; length posterior wing, 74.3 mm. [Undoubtedly 14.3 mm.]

Country, Toronto (Canada), June 1, 1908. A specimen in my collection donated by Sr. Duchassoy de Caudebec les Elbeuf (France)."

It is difficult to determine the distinctive features from this very general description. The type is probably a badly faded specimen which has lost important features that characterized it in life.

One specimen was found in the Canadian collection which conforms very largely to this description. It was collected by G. S. Walley, Kazubazua, Quebec, August 16, 1927.

UNCLASSIFIED SPECIMENS IN THE CANADIAN NATIONAL MUSEUM.

The following two forms are represented in the Canadian collection by single specimens. An effort should be made to collect other representatives which would aid in establishing their identity and relationships. The author hesitates to apply new names to the single specimens because there is strong possibility of obtaining additional representatives.

1. **Chrysopa species** near **rufilabris** Burm.

The wings, antennae and body characters are like *rufilabris*. There is a small, pink dot each side of the clypeus. The palpi have an elongate brown spot on the outside of each segment. These spots do not form the usual brown line. The face and vertex are very yellow and without markings. There is a marked light yellow dorsal band, along each side of which there is some brown coloration which however is probably secondary. The yellow dorsal band extends to the end of the abdomen. Total length 13.5 mm. Collected by G. S. Walley, Kazubazua, Quebec, August 16, 1927.

2. **Meleoma sp.** near **emuncta** Fitch.

The writer is not positive that this is a species of *Meleoma* as the specimen is a female. The antennae are pale and without marks. The vertex and front are deep yellowish-green and there is a pair of black dots each side of the clypeus as in *C. nigricornis*. The palpi are broadly banded with light brown, making them appear predominately brownish. The body is uniformly greenish-yellow. The veins are all entirely bluish-green, there being no brown veins. The wings are noticeably broad and rounded. The gradate series in the front wings are 12 (outer) and 11 the upper two in the inner series being double in both wings. The stigmas are prominent, yellowish-green, with a regular series of well developed cross veins in all.

Collected by Kenneth M. King, Saskatoon, Sask., July 9, 1923.

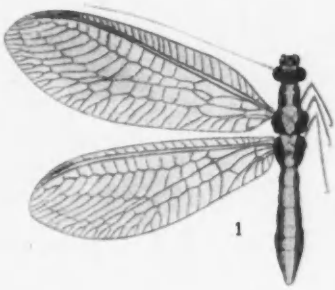
LITERATURE CITED.

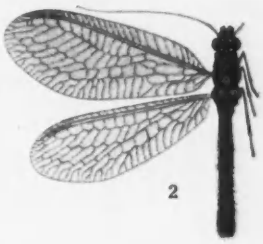
Banks, Nathan. 1892. "A synopsis, catalogue and bibliography of the neuropteroid insects of temperate North America." Trans. Amer. Ent. Soc. 19: 327–373.
1895. "New neuropteroid insects." Trans. Amer. Ent. Soc. 22: 313–316.
1896. "A new species of Meleoma." Ent. News 7: 95–96.
1898. "Three new species of Chrysopidae." Proc. Ent. Soc. Wash. 4: 173–175.
1903. "A revision of the nearctic Chrysopidae." Trans. Amer. Ent. Soc. 29: 137–162, 1 pl.
1906. "Three new species of Neuroptera." Psyche 13: 98–100.
1907. Catalogue of The Neuropteroid Insects of The United States (Except Odonata). Amer. Ent. Soc., Phila., 33: 1–53.
1908. "Neuropteroid Insects—Notes and Descriptions. Trans. Amer. Ent. Soc. Phil., 34: 255–267, pl. 17–19.
1911. "Descriptions of new species of North American neuropteroid insects." Trans. Amer. Ent. Soc. 37: 335–360, 3 pls.
1915. "Miscellaneous notes." Proc. Ent. Soc. Wash. 17: 146–147.

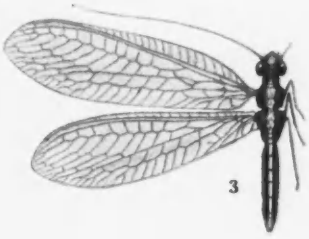
Burmeister, H. 1839. "Megaloptera." Handbuch der Entomologie 2: 968–1004.
Coquillett, D. W. 1890. Rept. Calif. State Board of Hort. p. 288.
Fitch, Asa. 1856. "Insects infesting fruit trees. I. The apple." First Rept. Insects State of New York, 5–104. (70–97 devoted to notes and descriptions of Chrysopidae and Hemerobiidae).
Hagen, H. A. 1861. Synopsis of the Neuroptera of North America. I–VIII and 1–347. Smithsonian Misc. Collections.
Lacroix, J. L. 1915. "Notes neuropterologiques." Bull. Ent. France (1915): 243–245.
1926. "Reflexions sur le genre Cintameva Navas." Compt. Rend. Assoc. Franc. Advanc. Sci. 49: 436–438, (1925) 1926.
Leach, W. E. 1815. "Entomology." (Brewster) Edinb. Encycl. 9: 57–172.
McLachlan, Robt. 1868. "A monograph of the British Neuroptera-Planipennia." Trans. Ent. Soc. Lond. (for 1868): 145–224, 4 pls.
1869. "New species, &c., of Hemerobiina; with synonymic notes (First Series)." Ent. Month. Mag. 6: 21–27.
Navas, R. P. L. 1912. "Neuropteros neuvos de America." Broteria 10: 194–231.
1914. "Quelques neuropteres recueillis par le Dr. Malcolm Burr en Transcaucasia." Revue Russe d'Entomologie 14: 211–216.
1915. Chrisopids d'Europa. Arxios de l'Institut de Cienc. Barcelona. An. III, Num. 2. 98 pp., 3 col. pl.
Say, Thomas. 1839. "Descriptions of new North American neuropterous insects and observations on some already described." Jour. Acad. Nat. Sci. Phila. 8: 9–46.
Smith, R. C. 1922. "The biology of the Chrysopidae." Cornell Univ. Agr. Exp. Sta. Memoir 58: 1291–1372, 16 pls.

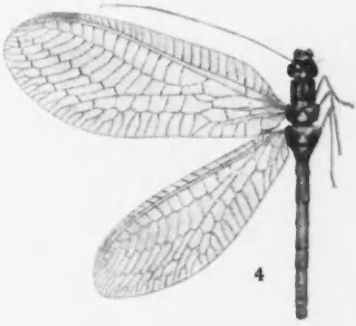
EXPLANATION OF PLATE.

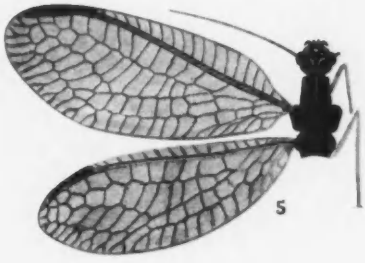
1. *Chrysopa plorabunda* Fitch.
2. *Chrysopa pleuralis* Banks.
3. *Chrysopa downesi* Smith.
4. *Chrysopa oculata* var. *oculata* Say.
5. *Nothochrysa californica* Banks.
6. *Chrysopa coloradensis* Banks.

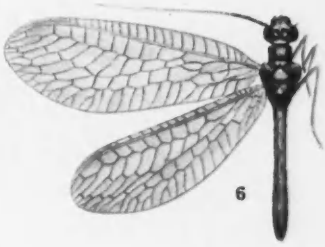

1


2


3


4


5


6

BLOODSUCKING AND NON-BLOODSUCKING FLIES IN RELATION TO HUMAN WELFARE

Symposium Before the Society at its Twenty-sixth Meeting, New Orleans, Louisiana.

PAGE

1. Myiasis-Producing Diptera—F. C. BISHOPP. (Published elsewhere).
2. Bloodsucking Flies (Exclusive of Culicidae)—H. H. SCHWARDT..... 603
3. Mosquitoes in Relation to Human Welfare—E. HAROLD HINMAN..... 613
4. Non-bloodsucking Flies as Vectors of Pathogenic Micro-organisms—W. B. HERMS..... 623

Discussion of Symposium Papers—ERNEST CARROLL FAUST..... 629

BLOODSUCKING FLIES (EXCLUSIVE OF CULICIDAE) IN RELATION TO HUMAN WELFARE.[1]

H. H. SCHWARDT,
University of Arkansas.

Bloodsucking flies are an important factor affecting both the physical and economic welfare of man. During the last sixty years the intimate relation between these insects and human disease has been clearly demonstrated. Although the transmission of disease is their most important role, bloodsucking flies are guilty of various depredations which bring annoyance and loss to man. Considerable areas in some countries are made uninhabitable and nearly worthless by the perennial presence of mosquitoes, sand-flies, or black flies. The annual loss suffered by the meat and dairy industries, though difficult to estimate accurately, must be great.

The bloodsucking species of *Diptera* are divided among eleven families, and number approximately three thousand. It is obviously impossible, therefore, to put anything approaching an adequate treatment of this large group into a short paper. Only a few facts of interest relating to the more important species in each family can be given. The relation of each group to disease transmission is only briefly stated, since this subject is fully treated in the other papers composing this program.

Before entering into an account of the various blood-sucking groups, it should be worth while to consider briefly the evolutionary lines along which the bloodsucking habit has been developed. Pertinent observations on this subject were made by Frederick Knab (8) (10) (11), on species of Leptidae and Ceratopogoninae. He found that the Leptid *Symphoromyia hirta*, although able to bite and take blood, usually fed on blood oozing from the recent bites of other flies, especially Tabanidae. In the

[1]Research Paper No. 262, Journal Series, University of Arkansas.

Chironomid subfamily Ceratopogoninae, Knab observed a series of species which seem to demonstrate clearly how blood feeding was developed in that group. He found in that family a species which fed on phytophagus lepidopterous larvae, another species which took its food from recently engorged mosquitoes, and finally, several species which fed entirely on mammalian blood. Thus an almost complete picture is given of the transition from phytophagus to haematophagus feeding.

The observations of Patton and Cragg (17) on certain Indian Muscidae are also interesting from the evolutionary standpoint, but it seems uncertain whether the species concerned represent development toward or away from the habit of bloodsucking. These investigators found that *Musca pattoni* and three related species all have an insatiable appetite for blood. These flies, however, are unable to break the skin of their hosts, so resort to close association with species of *Stomoxys*, *Tabanus*, or *Philaematomyia*. Patton has seen as many as eight of these flies clustered about a single feeding *Stomoxys*, waiting for it to withdraw its proboscis.

Evolution toward blood feeding is apparently a slow and difficult process, accompanied not only by changes in mouthparts, but also by the development of digestive secretions, capable of converting mammalian blood into food elements useful to the insect. Lester and Lloyd (12) found that the salivary secretions of the tsetse flies contain a powerful anti-coagulin which keeps ingested blood in a liquid state while passing the narrow anterior portions of the digestive tract. Flies from which the salivary glands were removed lived and fed for a time, but eventually died as the result of blood clots congesting the esophagus and proventriculus. The hinder part of the mid-intestine of these flies contains a powerful coagulin which clots the liquid meal, thus holding it in place while digestion and assimilation take place.

THE FAMILIES OF BLOODSUCKING DIPTERA.

The exact status of a few dipterous families, as regards bloodsucking, is obscure. In an early paper, Kellogg (6) states that "the females of *Blepharocera*, like those of *Simulium*, *Ceratopogon*, *Dixa*, *Culex*, and some other *Nematocera* are bloodsucking." This association immediately classifies *Blepharocera* and *Dixa* as blood-thirsty, but if such is the case, it is seldom mentioned in the literature. Knab refers to the Blepharocerid *Curupira torrentium* as "an habitual bloodsucker," but no other reference to this habit in either family has been found. This perhaps is due to the small number of species in these genera, and to their rare occurrence in numbers.

The more notorious bloodsuckers of the *Nematocera* are found in the families Psychodidae, Chironomidae, Culicidae, and Simuliidae.

THE FAMILY PSYCHODIDAE.

Among the Psychodidae, the bloodsucking habit is confined almost entirely to species of the genus *Phlebotomus*, commonly known as sand-

flies. These flies are inhabitants chiefly of the tropical and subtropical regions of the world. *Phlebotomus vexator* has been described from the United States. Though small in size and number of species, these flies occur in enormous numbers in many regions, causing much annoyance by their bites and spreading disease. Early investigators always associated these insects with caves, mountain canyons, ruined masonry, and the like, but King (7) has shown that in Africa they also breed in damp earth and sand. He has found great swarms of sand-flies far out in the desert and well removed from any usual breeding places. He also reared several adults of *Phlebotomus papatasi* from soil taken in a citrus grove. Sand-flies and the diseases which they transmit are especially prevalent in Sicily, Corsica, and other Mediterranean islands abounding in earthquake ruins, which form ideal breeding places for the flies. The adults are mostly crepuscular or nocturnal, and some species seem to prefer altitudes of three to five thousand feet. They are low fliers, however and frequently complete immunity from their bites is obtained by sleeping in the upper story of a house. Several species appear to take most of their food from lizards and batrachians, man being only an incidental host.

Phlebotomus papatasi is the carrier of Pappataci fever. According to Townsend (20), the Peruvian disease known as Verruga is transmitted by *P. verrucarum*. Oriental Sore, a Leishmania disease common in southern Asia, appears to be transmitted by a species of *Phlebotomus*, and these flies have been suspected as carriers of *Leishmania donovani*, the protozoan which causes *Kala Azar*.

THE FAMILY CHIRONOMIDAE.

The family Chironomidae, though composed mostly of harmless or beneficial species, has one subfamily, the Ceratopogoninae, which includes many bloodsucking species. The microscopic size of these midges and the disproportionately large pain which accompanies their bites led Lugger (13) to write, "It is a mere speck of matter, and it is difficult to understand how this small being can harbor the vast amount of 'cussedness' it is known to possess."

The larvae of these flies are found in water-filled holes in trees, at the edges of woodland streams, under rotting logs and dung, and in small tidewater pools at the seashore where they are often numerous. Painter (15) found larvae of the Honduran *Culicoides furens* developing in puddles composed almost entirely of sea water.

The possibility of disease transmission by Ceratopogoninae is remotely suggested by the feeding habits of certain Malayan species of *Culicoides* which take blood from engorged *Anopheles* mosquitoes. It is not surely known, however, that this *Culicoides* also feeds on man. At most it could be only a supplementary carrier.

THE FAMILY SIMULIIDAE.

Few insects are more capable tormentors of animals and man than certain species of Simuliidae, known variously as black flies, buffalo gnats, or sand-flies. One who has never been the victim of their bites

cannot fully appreciate the suffering which accompanies and follows them. The flies often appear suddenly in great clouds, and on such occasions are able, within a few hours, to cause the death of large animals and even man if he is not well protected. Black flies were a particular menace to early settlers in North America who were entirely dependent on horse or ox-drawn wagons for transportation. Many small pioneer companies suffered great hardship as a result of sudden destruction of their draught animals by black flies.

A few investigators have suggested that the occasional rapid death of animals attacked by black flies may be due to inhaling the flies in such quantities as to obstruct the bronchi. This theory is sustained in part by the observations of Enderlein (3) in Bulgaria. He reports that horses, cattle, goats, and hogs may be killed in only half an hour when the black flies are exceedingly numerous. Such a rapid effect would seem to be due to suffocation rather than to the bites of the flies. It is more generally believed, however, that death is caused by toxins injected while the flies are biting.

A few species of Simuliidae attack lepidopterous larvae.

Black flies are widely distributed. In North America they inhabit every latitude from Labrador to the tropics. The immature stages live on submerged objects in rapidly flowing streams, but the adults apparently are not bound to such an environment. Great swarms have occurred in areas drained by sluggish watercourses, and at times when previous floods could not have been a factor. Aided by wind, the adults undoubtedly can travel long distances over prairie country.

Black flies have at times been suspected as carriers of various diseases, especially pellagra. Recent work, however, has shown this disease to be due to dietary deficiencies, especially the lack of vitamin G.

THE FAMILY LEPTIDAE.

Only two families of the *Brachycera*, the Leptidae and the Tabanidae, contain flies which feed on the blood of mammals. Less than a score of species of Leptidae are known to take blood, and these are local in distribution. The genus *Symphoromyia* contains the species which are most frequently troublesome in North America. *Symphoromyia hirta* Johnson, originally described from Pennsylvania, has been reported from Colorado by Cockerell, and from Utah by Stanford. Williston's *S. pachyceras*, which he took in northern California, has also been reported by Cooley, as a persistent bloodsucker in southwestern Montana. In 1928 Hearle (4) found *S. atripes* so abundant in British Columbia that horses frequently became unmanageable as a result of its bites.

Five Australian and one Tasmanian species of *Spaniopsis* are haematophagus, as are *Atherix longipes* of Mexico, *Dasyomma obscurus* of Chile, and *Symphoromyia grisea* of Italy.

Because of their limited numbers and local distribution, the blood-sucking Leptidae are not pests of major importance.

THE FAMILY TABANIDAE.

The family Tabanidae contains more species which take mammalian blood than any other insect group except the order Diptera itself. About two thousand species have been described, of which more than three hundred are from North America. They are widely distributed, occurring in profusion about the equator, and having been taken at the arctic circle.

They exhibit a considerable variation in size. Small specimens of *Chrysops obsoletus* are half the size of a house-fly, while *Tabanus americanus* approaches the proportions of the larger Mydas flies.

The Tabanidae are principally pests of dairy, meat, and draught animals, but a few species are strongly attracted to man. Several members of the genus Chrysops, especially *C. parvulus*, *C. moechus*, and the West Indian *C. costatus*, will bite human beings whenever the opportunity occurs. *Tabanus pumilus*, which has many habits in common with species of Chrysops, often leaves cattle to attack man. *Diachlorus ferrugatus*, known in Virginia as the yellow fly of the dismal swamp, is recorded by Banks (1) as one of the most annoying of the biting flies which attack man. The bites are painful and remain swollen and inflamed for nearly two weeks.

As vectors of disease, the Tabanidae have been variously accused, and experimental evidence against them has been obtained as transmitters of anthrax, surra, tularaemia, and the East Indian Buffalo Disease.

Studies on the habits and the biologies of horse-flies have revealed many unusual habits and abilities which explain in part the success of the group. Their swiftness of flight has been commonly observed, and Lugger (13) appropriately wrote, "they can not only follow an express train, but can make excursions into the country at the same time." They have been seen to circle an automobile travelling at forty miles an hour, then alight on it without difficulty. Rapid flight and large eyes make the horse-flies difficult to approach, and protect them almost completely from the awkward gestures of defense made by their hosts. The larvae live and develop successfully in many types of environment. The larvae of *Chrysops* and *Tabanus* appear to prefer the mud borders of streams and ponds, but some are found in decaying logs, or in the soil of gardens or pastures. The larvae of a single species, *Tabanus atratus*, have been taken in mud, under rocks and logs, under moss on rocks, in masses of floating algae in irrigation ditches, and as the late Prof. J. S. Hine (5) has said, "they are frequently found in the most unexpected places." Most tabanid larvae are aggressive predators and seem to dominate whatever environment they occupy. They devour annelids, molluscs, and various arthropods, especially crustacea and insects. They are fiercely cannibalistic, so much so that a tabanid larva's chief hazard in life probably is that of being devoured by another of its own species soon after hatching and before the young larvae have dispersed.

Protective environment makes the larvae almost immune to attack by parasites and disease. From more than two thousand larvae, both

collected and reared, which the writer has had under observation at various times, no larval parasite has ever been reared. A bacterial infection which occasionally has killed laboratory specimens has never been seen in the field. The adults are sometimes destroyed by hymenopterous predators, but these appear to be unimportant. The minute hymenopterous egg parasites, however, appear to exert a considerable influence toward reducing the numbers of several species. One of these almost microscopic wasps often arrives at the oviposition site very soon after the female horse-fly begins depositing eggs, and the two work together, though for opposite purposes, till the egg mass is completed. This habit makes it possible for the parasite to oviposit on all the layers of eggs in the mass, while if it came after the mass was completed only the outer layer of eggs could be parasitized.

The feeding habits of adult and larval Tabanidae are in many respects both unique and interesting. Certain species of adults prefer definite parts of the animal as feeding sites. Thus *Tabanus atratus* and *Tabanus sulcifrons* prefer the ridge of the back; *Tabanus pumilus* almost invariably bites on the ventral surfaces; while *Chrysops pikei* is usually found about the face or ears. In taking a meal, the mouthparts are inserted and withdrawn several times, which greatly increases the annoyance, loss of blood, and danger of transmitting disease. It is recorded that certain East Indian species of Pangonia, which have unusually long mouthparts, feed while on the wing, and without alighting on the host. While the data supporting this record appear to be somewhat open to question, it may nevertheless be true. This manner of feeding is not uncommon among some related species of *Brachycera*, which visit flowers. The larvae are carnivorous and are capable of ingesting either liquid or solid food. The food is pierced and held by the head armature, while the vertically acting mandibles lacerate and force small particles of food into the digestive tract.

The eggs of the Tabanidae are usually placed in masses on vegetation or debris projecting above water. As a rule, masses are not placed in close proximity to one another, but the females of one species, *T. vivax*, like those of *Simulium*, often make great compound egg masses which may contain over a hundred thousand eggs deposited by a number of females. It is an interesting corollary that the eggs of this species are especially heavily parasitized. The shape and structure of the complete egg mass appear to be characteristic for each species, and incomplete masses frequently can be identified.

Practical efficient methods for controlling horse-flies are not known. Parman's work (16) with egg parasites in southern Texas has shown that ten to fifty per cent of the tabanid eggs deposited in that district are parasitized. Drainage, which is often recommended, is impossible in regions like the rice-growing districts of California, Louisiana, and Arkansas, or where horse-flies are breeding near ponds which supply stock water. Kerosene covered ponds such as Portchinsky (18) recommended for trapping adults which come to drink, probably would be effective for only a few species not including the worst North American pests.

THE FAMILY MUSCIDAE.

The family Muscidae contains some of the most highly-specialized and most destructive bloodsucking insects known. These are found principally in the genera *Glossina*, *Stomoxys*, *Haematobia*, *Philaematomyia*, *Stygeromyia*, *Bdellolarynx*, *Lyperosia*, and *Musca*. Of these genera *Glossina* is peculiar to Africa and a corner of Arabia; *Stomoxys*, *Haematobia*, and *Musca* are nearly cosmopolitan; while *Philaematomyia*, *Bdellolarynx*, and *Stygeromyia* are chiefly oriental. *Lyperosia* and *Bdellolarynx* are considered as synonymous with *Haematobia* by authors.

The tsetse flies, all of which belong to the genus *Glossina*, are the most important group of bloodsucking muscids directly affecting man. As vectors of sleeping sickness, they have brought death to countless thousands of African natives and many white men. Their transmission of *Trypanosoma brucei*, the causative factor of the highly fatal Nagana of domestic animals, has made it impossible to keep domestic stock in many parts of Africa. Colonization has been greatly retarded as a result.

According to Newstead (14), there are twenty species, one subspecies, and five varieties of tsetse flies. These are with one exception confined definitely to the African continent, and even there are distributed only from the southern boundary of the Sudan to the latitude of south Angola and Portugese East Africa. The only species of *Glossina* occurring outside of Africa at present is *G. tachinoides*, which occupies a small corner of southwestern Arabia. Four species of fossil tsetse flies have been taken from miocene shales in Colorado. This discovery led to the theory that trypanosomes transmitted by these flies may have caused the disappearance of the Equidae, and others of the larger mammals from North America. This theory is open to question, since the animal hosts of the African species are tolerant of the trypanosomes continually transmitted to them. Experimental evidence has shown that eight species of *Glossina* are transmitters of trypanosomes pathogenic to man or his domestic animals. The three species which most often transmit these organisms are *G. palpalis*, *G. morsitans*, and *G. brevipalpis*.

In their manner of reproduction, tsetse flies approach the pupiparous louse flies of the family *Hippoboscidae*. The female of *Glossina* deposits a single fully developed larva at intervals of several days, and the larva pupates as soon as it finds a suitable place. The pupae are found in various situations where sufficient moisture and protection from predators are at hand.

The control of tsetse flies and of trypanosomiasis has received the attention of the best medical and biological investigators in the countries concerned with African colonization. Much has been accomplished, but large districts still are made practically uninhabitable. Methods of control, both fantastic and practicable, have been tried, and a few of the latter have proved successful for limited areas. It has been found that villages located in extensive clearings and away from streams are practically free from the flies. The Island of Principe, off the west coast of Spanish Guinea, though previously heavily infested, was

entirely rid of tsetse flies in 1915 as a result of systematic destruction or disturbance of breeding places during the three years preceding. Wholesale destruction of big game in the hope of starving the flies and reducing natural reservoirs of trypanosomes has been seriously recommended by several investigators. Others believe the efficacy of such a measure is open to doubt, since some species of the flies are known to feed on smaller mammals, reptiles, and birds, and might find these entirely sufficient in the absence of the larger animals. Such destruction also might force the flies to concentrate on human hosts with a consequent large increase in human trypanosomiasis.

The stable fly, which is common in most habitable parts of the world, is one of the most injurious bloodsucking pests of live stock in North America. It is present wherever live stock is kept, and sometimes occurs in outbreak proportions in the small grain districts of the south and middle west. Bishopp (2), reporting the outbreak of 1912 which centered in north Texas, reported that 300 head of live stock, valued at $15,000, were destroyed in that district, while the production of dairy cows was lowered 40 to 60 per cent, and cattle and horses decreased 10 to 25 per cent in weight. The attack of hordes of the flies, often 1,000 on a single animal, also brought on acute attacks of Texas fever in animals already infected with the organism.

The stable fly readily attacks man and was at one time suspected of transmitting both pellagra and polyiomyelitis. Subsequent investigation has led to the conclusion that this fly is not concerned in the transmission of either disease. Experiments have shown the stable fly to be capable of transmitting anthrax, and infectious anemia of horses.

The horn fly, *Haematobia irritans*, is an introduced pest closely related to the stable fly, but only half as large. It was first taken in the United States at Camden, New Jersey, in 1887, and by 1894 had occupied the entire country. The horn fly is primarily a pest of cattle and spends most of its life on or near them. The eggs, larvae, and pupae are found almost exclusively in cow manure.

Haematobia alcis, a related species, was described and reported by Snow, who found it attacking moose in Canada.

Lyperosia exigua is a serious pest of buffalo in Australia and the East Indies. It is said to remain on animals continuously for as long as ten days, and thus at times be transported long distances.

The Muscid genus *Philaematomyia* is composed of three species, *insignis*, *lineata*, and *gurnei*, all of which feed on blood; and *P. insignis* is the most important bloodsucking fly in parts of India. It has also been taken in central Africa and the East Indies.

Species of the genus *Philaematomyia* have mouthparts much like those of Musca, except that the labellae are reduced and the prestomal teeth are larger, thus enabling the fly to make a wound from which it can take blood. However, one species, *P. lineata*, is unable to puncture the skin and so, like the blood-feeding species of Musca, must take its food from punctures made by its better equipped relatives. In the mouthparts of *Stomoxys* the labellae are greatly reduced, the mentum

is increased in length, and the prestomal teeth and interdental armature entirely cover the distal end of the proboscis. Thus, *Philaematomyia* shows something of the evolutionary path connecting *Stomoxys* and *Musca*.

Stygeromyia maculosa, a biting fly which resembles the tsetse flies in appearance, has been taken by Patton at Madras. It is crepuscular and therefore seldom seen. Though related to *Glossina*, this species is oviparous.

THE FAMILY HIPPOBOSCIDAE.

The Hippoboscidae, or louse flies, are degenerate Diptera which have adapted themselves to more or less continuous existence on the bodies of birds or mammals. There are thirteen North American genera which together contain about thirty-five species.

The two species of greatest importance in North America are the so-called sheep "tick," *Melophagus ovinus*, and the pigeon fly, *Pseudolynchia maura*. The sheep tick is especially injurious to young lambs, to which it migrates in large numbers when the older sheep in a flock are sheared. The pigeon fly is capable of causing serious annoyance to young pigeons. Squabs frequently are infested with 20 to 30 of these flies, which, considering the relatively large size of the flies, must be a considerable burden to the birds. In addition to taking blood, the pigeon fly is the carrier of pigeon malaria, a disease which though mild lessens the vitality of the birds. *Pseudolynchia hirsuta*, a parasite of quail in California, is believed to transmit a species of *Haemaproteus* which is pathogenic to the birds.

Wild birds, especially hawks and owls, are often infested with louse flies. These, as well as the pigeon fly, are a source of annoyance not only to the birds but to taxidermists and to men who prepare squabs for market.

Biting lice of birds have occasionally been found clinging to the bodies of bird-infesting *Hippoboscidae*, and it appears probable that the distribution of some mallophaga is aided by these flies.

Two families, the *Streblidae* and *Nycteribidae*, which are closely related to the *Hippoboscidae*, are parasitic on bats and unimportant in the affairs of man.

BLOODSUCKING MAGGOTS.

In a few species of Muscidae, the bloodsucking habit has been developed only by the larvae. Such habits are represented in the North American fauna by the bird maggots which are larvae of *Protocalliphora chrysorrhea*, *P. metallica*, or *P. splendida*. Larvae of these species inhabit the nests of birds, especially thrushes and sparrows, where they feed on the blood of the nestlings. Pupation occurs in the nest material. As many as 154 larvae and pupae of *Protocalliphora splendida* have been taken from a bluebird's nest. Such heavy infestations sometimes cause the death of some of the nestlings, either directly or by forcing them out of the nest to be killed by predatory birds or animals.

The Congo floor maggot, which is the larva of *Aucheromyia luteolata*, is a common pest in Africa, occurring over most of the continent south of the Sahara desert. These larvae live in the dirt floors of native huts, coming out only at night, to take blood from the occupants as they sleep on mats on the floor. The larvae, which are unable to climb, are entirely dependent for their existence upon the native habit of sleeping on floor mats. Raising the mats even a few inches from the floor gives the sleeper complete protection.

Larvae of several species of the related genus *Cheromyia* live in the burrows of African ant bears, attacking them as well as the inquiline warthogs.

Regarding the mechanics of feeding of these larvae, Raubaud (19) has observed that the first postcephalic segment forms a suctorial cup into which the head is invaginated during feeding. Scarification of the skin is accomplished by the mouth hooks, and movements of the invaginated head develop the negative pressure which serves both to withdraw blood and to attach the larva to its host. The feeding habits of these larvae and their systematic proximity to certain dermal parasites of the genus *Cordylobia* suggest, according to Raubaud, that they represent a step in the development of permanent cuticular parasitism.

LITERATURE.

1. **Banks, Nathan.** 1904. The yellow fly of the dismal swamp. Ent. News, 15: 290–291.
2. **Bishopp, F. C.** 1913. The stable fly an important livestock pest. Jour. Econ. Ent. 6: 112–126.
3. **Enderlein, G.** 1924. Die Simuliiden Bulgariens und ihre Schaden im Jahre 1923. Zool. Anz. 61: 280–288.
4. **Hearle, E.** 1928. Insects of the season 1928 in British Columbia. Insects affecting live stock and man. Ent. Soc. Ont., Ann. Rept. 59: 35–37.
5. **Hine, J. S.** 1906. Habits and life histories of some flies of the family Tabanidae. U. S. D. A. Bur. Ent. Tech. Ser. Bul. 12, Pt. 2, 19–38.
6. **Kellogg, V. L.** 1900. Note on the life history and structure of *Blepharocera capitata* Lowe. Ent. News 10: 306–318.
7. **King, H. H.** 1914. Observations on the breeding places of sand flies (Phlebotomus sp.) in the Anglo-Egyptian Sudan. Jour. Trop. Med. and Hygiene 17: 2–3.
8. **Knab, F.** 1912. Blood-sucking and supposedly blood-sucking Leptidae. Ent. Soc. Wash. Proc. 14: 108–109.
9. ———, and **Cooley, R. A.** 1912. Symphoromyia as a blood-sucker. Ent. Soc. Wash. Proc. 14: 161–162.
10. ———. 1914. Ceratopogoninae sucking the blood of other insects. Ent. Soc. Wash Proc. 16: 139–141.
11. ———. 1915. Dipterological miscellany. Evolution of the blood-sucking habit. Ent. Soc. Wash. Proc. 17: 38–40.
12. **Lester, H. M. O.** and **Lloyd, L.** 1928. Notes on the process of digestion in tsetse flies. Bul. Ent. Res. 19: 39–60.
13. **Lugger, O.** 1896. Insects injurious in 1896. Minn. Agr. Expt. Sta. Bul. 48: 1–257.
14. **Newstead, R.** 1924. Guide to the study of tsetse flies. The University Press, Liverpool.
15. **Painter, R. H.** 1926. The biology, immature stages, and control of the sand flies (biting Ceratopogoninae) at Puerta Castilla, Honduras. Med. Dept. United Fruit Co. Rept. 15: 245–262.

16. **Parman, D. C.** 1928. Experimental dissemination of the tabanid egg parasite *Phanurus emersoni* Girault, and biological notes on the species. U. S. D. A. Cir. 18, 1–6.
17. **Patton, W. S.** and **Cragg, F. W.** 1913. On certain haematophagous species of the genus *Musca* with descriptions of two new species. Ind. Jour. Med. Res. 1: 11–23.
18. **Portchinsky, L.** 1915. (Tabanidae and the simplest means of destroying them.) Mem. Bur. Ent. of the Sci. Comm. of the Central Board of Land Administration and Agriculture, Vol. 2, No. 8, 1–58. Petrograd.
19. **Raubaud, E.** 1913. Recherches sur les Auchmeromyies, Calliphorines a larves suceuses de sange de l'Afrique tropicale. Bul. Scient. de la France et de la Belgique, 47: 105–202.
20. **Townsend, C. H. T.** 1913. The vector of Verruga, *Phlebotomus verrucarum* sp. n. Insecutor Inscitiae Menstruus 1: 107–109.

MOSQUITOES IN RELATION TO HUMAN WELFARE.

E. Harold Hinman.[1]

There are numerous early accounts of the prodigious swarms of mosquitoes and of the untold suffering they have inflicted upon man and his domestic animals. The adults have resisted the invasion of the human race into various regions of the world and many of these districts are still uninhabitable due to the ravages of the pests. Someone has said, "Man never discovered the mosquitoes, they discovered him." These insects have also exerted a marked influence in the economic world by the reduction in land values, real estate, etc., due to their excessive abundance. Especially is this true in certain of our coastal states where the salt marsh mosquitoes present a formidable menace. Sportsmen, both hunters and fishermen, find the Culicidae to be their greatest enemies. However the mechanical irritation produced by the bites of mosquitoes is a small item when one considers the rôle they play in the transmission of malaria, dengue fever, yellow fever and filariasis and they become of paramount importance to the medical entomologist.

MALARIA.

Malaria is believed by many to have had no small part in wiping out the old Greek civilization and today it remains the most important disease of the tropics and subtropics from the standpoint of morbidity and of economic loss to the community, though not from the point of view of mortality. As early as 1897 it was demonstrated that the anopheline mosquito was the transmitter of malaria and since that time active anti-larval campaigns and other measures have been undertaken to eradicate the infection.

---

[1]National Research Fellow in the Biological Sciences. From the Parasitology Laboratory, Department of Tropical Medicine, Tulane Medical School, New Orleans, La.

The plasmodia live and multiply asexually within the red blood corpuscles. At certain intervals there appears a sexual stage with the production of gametocytes which remain within the blood cells until these corpuscles are ingested by an anopheline. Within the alimentary canal of the insect host the sexual cycle is completed and is followed by sporogony with the final liberation of the sporozoites into the body cavity. These migrate in large numbers to the salivary glands and when the infected mosquito bites, the sporozoites are injected into the wound along with a small drop of saliva which supposedly impedes the clotting of the blood. The cycle within the definitive host requires from 8–14 or more days. To date there is no proof that malaria may be transmitted mechanically by the insect.

Not all *Anopheles* are suitable definitive hosts for the plasmodia nor are all those species which have been convicted on either epidemiological or experimental grounds of importance in the transmission of malaria. Out of a total of about 150 species from the entire world there are only approximately 60 anophelines in which either definite or presumptive evidence exists as to the transfer of this disease. Probably only 27 deserve serious consideration as *efficient* transmitters. Certain of these, however, are of widespread distribution and we find the following number of representatives from the various continents.

THE NUMBER OF IMPORTANT TRANSMITTERS.
(See Covell's list.)

North America	4
Central America and West Indies	2
South America	4
Europe	3
Africa	6
Asia	15
East Indian Archipelago	9
Australia, Melanesia and Polynesia	1

In the United States we have the following anophelines. *A. quadrimaculatus* Say is widely distributed and abundant throughout the Mississippi Valley and east to the Atlantic seaboard, extending from Mexico to Canada. This species is an excellent transmitter of the infection. *A. maculipennis* Meigen is abundant throughout most of California and somewhat scattered along the northern border of the United States. The species is one of the best known transmitters of malaria. *A. crucians* Wied., ranges from southern New York along the coastal region to Florida. Under experimental conditions it is a successful transmitter but, except for certain limited areas of its range, it is not considered to be of great importance. *A. pseudopunctipennis* Theo. is present in most of California and rare in Texas, New Mexico and Arizona. It is a carrier of malaria in Argentina, but not known to be so in the United States. *A. punctipennis* Say is the most widespread species of Anopheles in this country, ranging throughout the entire Eastern and Central States, in addition to California. While it is susceptible to infection experimentally yet there is slight or no epidem-

iological evidence indicating transmission. *A. albimanus* Wied., recorded from Key West, Fla., and the Rio Grande Valley in Texas, is considered to be a dangerous carrier of malaria in Central and South America but within the confines of the United States could be of only local importance. *A. atropos* Dyar & Knab is confined to the Gulf Coast of the United States from Florida to Louisiana. Recent experiments show it to be susceptible to infection. *A. walkeri* Theo., has been recorded from Michigan, Massachusetts, Maryland, Virginia and Louisiana and *A. barberi* Coq., whose larvae inhabit treeholes is restricted to the eastern United States from New York southward. Neither of these latter two species has been found abundantly nor is their rôle in the transfer of malaria known.

Malariologists are interested in the biology of anophelines in so far as it throws light on the epidemiology of the disease or offers possibilities for the control of the insects. The larvae usually breed in relatively clear still waters of various types of pools, ponds, etc., frequently associated with algae. They are generally rural or limited to the suburbs of cities. It is now known that certain anophelines are capable of a flight of from 2–6 miles in search of a blood meal. They are in general crepuscular, confining their activities to the twilight hours of both morning and evening, but there are exceptions to this statement, e. g., *A. atropos* readily attacks by day. During the daylight hours anopheline adults usually select some dark or shaded position for resting. The length of life of an infected female is of the greatest importance and it has been found that they may survive up to a period of 125 days. The plasmodia are able to resist temperatures between 0–8° C., and it is apparent that under certain conditions the females may transmit infection after hibernation.

It has been suspected that possibly certain animals may serve as reservoirs for this disease, but there is no good evidence that the human parasites have ever been successfully transmitted to mammals either by injection or by mosquito transmission. Although certain plasmodia of monkeys are morphologically similar to those of man yet experimental work indicates that they are not identical with the human species. Thus only human gametocyte carriers are reservoirs for mosquito infection.

Some anophelines show a marked preference for human blood (androphilism) while others exhibit a predilection for the blood of domestic or wild animals (zoophilism). Specific predilections have been determined by employment of the precipitin test in examining the stomach content of engorged females. The fact that certain data indicate *A. crucians* and *punctipennis* to be zoophilic may be significant when one considers the absence of epidemiological evidence against these species. A few authors have recommended the housing of cattle and other domestic animals in close proximity to dwellings in an effort to reduce opportunities of infection in regions of low endemicity.

Recent work indicates that there is no true correlation between the numbers of gametocytes in the malarial patient's blood and his ability to infect mosquitoes, the quality of the gametocytes being the important

factor since many of them may be sterile. The species of *Anopheles* considered did not become infected if the number of exflagellating male gametocytes, in a moist chamber preparation kept at 25° C., fell below 1 to 1,000 leucocytes.

A rather alluring hypothesis, based on purely observational evidence, to account for the absence of malaria in stated regions where anophelines exist, attributes this to the presence of legumes containing coumarin. This drug is thought to have an effect on parasitized mosquitoes similar to that of quinine on the plasmodia in man. A list of 81 spp., of coumarin-containing plants has been published recently. However, experimental evidence in support of this explanation seems to be lacking.

Methods of control can be merely mentioned. There is little doubt that the greatest decline in malaria, the world over, has been brought about by anti-larval measures. Chief among these in recent years has been Paris green dusting by aeroplane, power blowers on motor boats, etc. The most permanent measures are drainage or filling and grading. Oiling is effective under certain circumstances. Biological control by natural enemies may be successful in some cases. Since the larvae remain at the surface, top-feeding minnows such as *Gambusia* are utilized. Control of the adult becomes more difficult. Screening is a necessary prophylactic measure in malarious regions. Traps are beneficial and the recent electrocution methods may prove helpful. The destruction of anophelines in houses is indicated especially since many malariologists recognize the infection as a "family" disease, i. e., a much higher incidence in homes with the greater number of inhabitants. However it must be appreciated that any given locality will require its own modification of control measures.

So far as is known to the writer the only item which may be put to the credit side of the ledger account with mosquito activities is their utility in the transfer of malaria to paretics, etc. For some time it has been known that the high temperatures induced by malarial fevers have a therapeutic value in the treatment of paresis and certain other nervous disorders. The infection by means of anophelines is the most satisfactory method from the point of view of the patient since it is simpler and there is no danger of introduction of such infections as syphilis and malignant malaria. By incubating the anophelines at 22° C., the malignant parasite, requiring a higher temperature than the benign tertian, has its development inhibited in the mosquito. It is true that the labor involved in maintaining infective anophelines is considerable but in one instance a single mosquito has been successful in infecting 11 individuals. Owing to the excessive cost of diathermy it probably will not displace the malarial treatment promptly.

A discussion of malaria cannot be dismissed without at least a reference to Blackwater Fever. The etiologic agent of this fever is at present unknown, but there is no doubt that the disease is closely associated with repeated attacks of malaria and until this is disproven anophelines must assume an indirect responsibility.

YELLOW FEVER.

Epidemics of Yellow Fever have ravaged the Western Hemisphere for centuries and have frequently appeared in West Africa. Until the beginning of the present century no measures were available for control and it was not eliminated from the United States till 1905. In 1900 its transmission was demonstrated to be by a single species of mosquito now recognized as *Aedes aegypti* Linn., and prophylaxis has been by anti-mosquito measures.

The virus of Yellow Fever is found in the peripheral blood stream of the patient during the first three days of the fever and to become infective a mosquito must bite during this stage of the disease. Within the insect host the virus evidently undergoes a development since it requires a period of approximately 12 days before the mosquito becomes infective. Once it reaches this condition the host remains capable of transmitting the disease for the rest of its life, exceeding 3 months in some cases. According to the most recent evidence the virus is non-hereditary in the mosquito nor is there any experimental work indicating the possibility of mechanical transfer, although quantities of infective blood as small as one ten-millionth to one billionth of a cc. have proven fatal.

The distribution of *Aedes aegypti* includes the warmer regions of Europe, Asia, Africa, Australia and America between 38° north and 38° south latitude. The mosquito rarely occurs above 3,000 feet elevation. It is the most thoroughly domesticated species known, the larvae breeding almost exclusively in artificial receptacles in and around habitations. They seem to breed equally well in clear or slightly contaminated water. Seldom are they found more than a few hundred yards from dwellings and the adults are incapable of longer flight. The latter normally inhabit homes and are most active during the daylight hours though they will feed at night. A marked preference for human blood is shown and it is extremely doubtful if domestic mammals are attacked other than in exceptional circumstances. The adults are prone to remain in the same house in which they have been feeding.

Prior to 1928 no experimental animal, other than man, was known to be susceptible to Yellow Fever; neither was any species of mosquito other than *Aedes aegypti* known to be capable of transferring the infection. In 1928 it was discovered that the Indian monkey *Pithecus* (=*Macacus*) *rhesus* was susceptible either by the bite of infected mosquitoes or by the direct inoculation of blood or organs containing the virus. This opportune advance was the most outstanding achievement in the epidemiology of Yellow Fever since 1900 and made possible valuable contributions to the study of the infection from the point of view of transmission, immunity, etc. The disease in monkeys produces pathological changes almost identical with those observed in human cases but the virus is present in the blood throughout the course of the malady which provides greater opportunities for mosquito infection. In addition to *Pithecus rhesus* there are 24 other species of monkeys which have been shown to be susceptible to Yellow Fever either by the bite of infected mosquitoes or by inoculation experiments. They

include such divergent groups as marmosets, squirrel, spider and red howling monkeys. Of the total of 25 species, 14 are New World and 11 Old World representatives. As well as monkeys it has been found that white mice may be infected intracerebrally, guinea pigs may maintain the virus and there is evidence that it is recoverable from dogs and cats up to a period of 30 days after inoculation. The question as to whether these animals may serve as sources of infection is one of great importance. In the case of certain African monkeys it has been demonstrated that wild specimens are not susceptible, presumably due to an early attack with the resultant permanent immunity. However, it must be remembered that the disease is spread from monkey to monkey by mosquitoes and there is no reason to believe that the infective insects would not attack man if the opportunity were afforded.

Unfortunately it has been determined that *Aedes aegypti* is not the only successful transmitter of this infection under experimental conditions.

TRANSMITTERS OF YELLOW FEVER.

(Exclusive of *Aedes aegypti*)

AFRICA.

FROM MONKEY TO MONKEY BY BITE.

SPECIES	DISTRIBUTION	BREEDING HABITS
Aedes luteocephalus	Ethiopian	Treeholes and cut bamboos.
A. stokesi (=**apicoannulatus**)	West Africa	Treeholes, banana stumps, cut bamboos, etc.
A. vittatus	Ethiopian and Oriental	Rock pools, cement drains, gutters, etc.
A. africanus	Ethiopian	Treeholes, banana stumps, tins occasionally — semi-domestic.
A. simpsoni	Ethiopian	Treeholes, leaf axils.
Eretmopodites chrysogaster	Ethiopian	Treeholes, tins, banana stumps.
Taeniorhynchus africanus[2]	Ethiopian, Oriental and Australian	Larvae and pupae attached to aquatic plants.

BY INJECTION OF SALINE SUSPENSIONS.

Aedes irritans **A. nigricephalus** **A. punctocostalis** **Culex thalassius**	West Africa, etc.?	Vicious biting crabhole mosquitoes.

SOUTH AMERICA.

FROM MONKEY TO MONKEY BY BITE.

Aedes fluviatilis	Brazil, French Guiana, Surinam	Rock holes along rivers.
A. scapularis	Greater Antilles, Colombia, Venezuela, Trinidad, the Guianas, Bolivia, Brazil	Temporary rain pools.

[2]Considered by Philip to be the most likely of the potential transmitters to be of epidemiological importance.

By Injection of Macerated Specimens.[3]

SPECIES	DISTRIBUTION	BREEDING HABITS
Aedes serratus	Mexico, Costa Rica, Panama, Colombia, Venezuela, the Guianas, Trinidad, Bolivia, Brazil	Temporary rain pools.
A. taeniorhynchus	Atlantic and Gulf Coast from New York to Mexico and Guianas, Antilles, Pacific Coast from So. California to Peru	Coastal marshes.

FAR EAST.

From Monkey to Monkey by Bite.

Aedes albopictus	Oriental	Similar habits to **Aedes aegypti.**
A. variegatus (=scutellaris)	Australasian	Treeholes, fallen cocoanuts, tins, etc., in bush.

Total=17 species; 11 by bite; 7 by inoculation of macerated infected specimens.

There is no reason to doubt that certain of these mosquitoes may transmit the disease from man to man because of the close parallel between the infection and the pathological changes in both the *rhesus* monkey and man. Further evidence in support of this hypothesis is found in the number of laboratory infections with virus that has been passaged through monkeys for long periods. These cases do not seem to differ from natural ones. Yet in the majority of epidemics to date it would seem that *Aedes aegypti* is undoubtedly the species involved. However the rôle that these other species play in maintaining the infection among monkeys must be considered.

The eradication of Yellow Fever should not be as difficult as Malaria since the major transmitter is a domestic mosquito. Control measures become largely a personal matter and educational propaganda plays an important part. If local cooperation can be secured, the artificial receptacles, which form the chief breeding habitats, may be emptied, screened, stocked with fish, oiled or treated with a larvicide such as borax. The question of screening against adults is of the greatest importance especially during an epidemic but provides numerous difficulties owing to the habits of the female which is certainly the most troublesome mosquito to exclude from residences.

At least a reference will be made to the possibility of the introduction of Yellow Fever into the United States. With the tremendous advance in rapid transport by aeroplanes the invasion of either infective mosquitoes or Yellow Fever patients becomes a mathematical possibility. It has recently been shown by U. S. Public Health workers that mosquitoes may survive aeroplane passage from Central and South America to the Southern United States. Furthermore the

[3]Six additional species have recently been incriminated, namely: *Aedes terrens, Psorophora cingulata, Psorophora ferox, Mansonia fasciolata, Mansonia chrysonotum,* and *Mansonia albicosta.*

League of Nations Epidemiological Reports cite sporadic outbreaks of this fever in Brazil and Colombia and record a marked increase in its prevalence in South America during the past four years. The reservoirs of this infection, consisting of the native population in these endemic areas afford a menace to us which becomes serious only with the advent of rapid transportation. Once an outbreak occurred in such a city as New Orleans the disease might well spread with surprising rapidity owing to the large number of *Aedes aegypti* present during various periods of the year. In countries where susceptible monkeys are abundant, e. g., India, the difficulty of eradication, in case of accidental introduction multiplies many times. Tests with *Aedes aegypti* from India have shown them to be capable of transmitting Yellow Fever from monkey to monkey.

DENGUE.

Dengue is an epidemic disease which may occur in almost any part of the tropical or subtropical world. It was first clearly defined in 1780 under the designation of break-bone fever, but the epidemiology was unknown until early in the twentieth century when mosquito transmission was demonstrated. While the infection is seldom fatal yet a serious problem is presented by the high morbidity in epidemics of this disease.

The virus seems to be in the blood stream only during the first three days of fever and the mosquito may become infected during this period or a few hours previous to the onset of the febrile condition. The insect remains infective throughout the remainder of its life (after the 9+ day incubation period)—in one instance 75 days. The virus is not known to be transmitted hereditarily by the mosquito. Certain recent investigators believe that the so-called incubation period of the virus in the mosquito is merely the time required for the virus to become concentrated enough in the insect to allow the injection of an infective dose. Furthermore since the virus may be transferred from infected to normal *Aedes* for at least three serial transfers in apparently undiminished potency, by feeding on a suspension of dengue infected mosquitoes, it appears doubtful if any cyclic development is undergone within the insect host.

The appearance of the disease in regions of the world, in which *Aedes aegypti* was not present, indicated that some other transmitter must be responsible. *A. albopictus*, an Oriental species, has been incriminated in Japan, Formosa, East Coast of Sumatra and other countries. This form is a common household pest breeding under similar conditions to those of *A. aegypti* and undoubtedly must be considered to be an important factor in the dissemination of dengue. It has been shown to remain infective for at least 54 days. *Armigeres obturbans* was found to be an experimental transmitter in Formosa. Recently it has been demonstrated that either *Culex quinquefasciatus* or *Aedes aegypti* may transmit sufficient virus mechanically, from man to man, to cause infection, provided large numbers of mosquitoes which have been interrupted in feeding on Dengue patients are imme-

diately allowed to complete their blood meal on a susceptible individual. This seems remarkable if one considers the inability to demonstrate the mechanical transfer in Yellow Fever, especially so, when the similarity of the virus of the two infections is recalled and also the potency of the virus of Yellow Fever. As more species are experimented with, undoubtedly additional transmitters will be found. Recent attempts with animal infection indicate that several species of Asiatic and African monkeys are susceptible and may be of importance in the maintenance and dissemination of Dengue in certain regions. Unquestionably these species will be useful in experimental work.

The southern United States has been subject to epidemics of Dengue as recently as 1922. The proper transmitter exists over a considerable territory and with the introduction of the virus a serious outbreak might easily result. Prophylactic measures against this mosquito have been considered in the section dealing with Yellow Fever.

FILARIASIS.

Filariasis due to infection with *Wuchereria bancrofti* occurs indigenously throughout the world from about 41° North to about 28° South latitude in the Eastern Hemisphere and from about 30° North to about 30° South latitude in the Western Hemisphere. In the United States only one area, that around Charleston, South Carolina, has been discovered. In 1878 Manson obtained experimental proof that *Culex quinquefasciatus* Say was the intermediate host, the first instance of an insect serving as a host for the intermediate development of a human parasite.

Manson found that the microfilariae usually exhibit a nocturnal periodicity in the peripheral circulation (maximum concentration between 10 p. m. and 2 a. m.) and a diurnal concentration in the pulmonary vessels, capillaries of the heart muscle and in the Malpighian tufts of the kidney. This fact is of great significance in regard to the opportunity of mosquito infection. In the appropriate host the microfilariae pass into the stomach with the blood meal, "exsheath," invade the stomach wall, migrate to the thoracic muscles and after an internal matamorphosis, moult and are ready to migrate down the labium of the mosquito and infect man. This development in the insect varies from a minimum of 10 days to six weeks or more.

Culex quinquefasciatus, the tropical house mosquito, is widely distributed throughout the warmer regions of the world between the 39th parallel of latitude north and south. The larvae occur mainly in artificial containers, including sewers, rain barrels, catch basins, etc., being rarely found in ground pools. This species is quite domesticated, infesting houses; biting at night. In the more temperate regions it is replaced by *C. pipiens*, a species almost identical with it in appearance and in breeding habits.

The following species are said to be efficient transmitters of *Wuchereria bancrofti:*

Culex quinquefasciatus—Widespread.
C. pipiens var. **pallens**—China, Japan.
C. sinensis—Japan.

C. tipuliformis—Japan.
C. tritaeniorhynchus—Japan.
C. whitmori—Japan.
Aedes aegypti—West Africa, New South Wales.
A. togoi—Japan.
A. variegatus (=**scutellaris**)—Pacific Islands.
Mansonia pseudotitillans—Malaysia.
M. uniformis (=**africanus**)—Central Africa.
Anopheles albimanus—Caribbean.
A. algeriensis—Tunis.
A. amictus—Australia.
A. costalis—West Africa.
A. hyrcanus var. **sinensis**—Japan, China.
A. nigerrimus—Travancore.
A. rossi—India.

18 species.

In at least 20 other species partial development of the parasite has been observed.

Certain of the above-mentioned efficient intermediate hosts have a rather wide distribution but as might be expected any particular species may show varying degrees of efficiency in transmission in different localities, e. g., *Culex quinquefasciatus* is said to be a much better transmitter in British India than in the Fiji Islands.

The control of this infection becomes an exceedingly difficult matter owing to the great diversity of breeding habits of the hosts. Where either *C. quinquefasciatus* or *C. pipiens* are responsible measures similar to those utilized for destruction of *Aedes aegypti* larvae will be found satisfactory. Owing to the nocturnal periodicity of the microfilariae, screening of houses is essential and the patients should especially be kept under mosquito bars during the night. Unless anti-larval campaigns are undertaken against all types of mosquitoes, in endemic regions, it is almost impossible to hope to eliminate the disease. Further research will probably add considerably to the list of intermediate hosts as the parasite shows little indication of "host specificity."

DERMATOBIA INFECTION.

In 1911 a mosquito was found with the eggs of *Dermatobia* glued to its abdomen. *Dermatobia hominis* (=*cyaniventris*) is a man-infesting bot-fly common in Tropical America from Mexico to Northern Argentina. The female fly when ready to oviposit seizes the mosquito and cements a packet of eggs (16–54) to the underside of its abdomen. The mosquito serves merely as a mechanical vector to transport the eggs and when it feeds on man or domestic animals the eggs are stimulated to hatch and the young larvae penetrate the skin of the mammalian host. The larva matures in the tissues within a period of 5–10 weeks and as it develops a sort of boil or cyst forms. If the larva moves within the tissues it gives rise to excruciating pain. When mature the larva drops to the ground to pupate.

The most important vector is *Psorophora* (*Janthinosoma*) *lutzi* but *P. posticata* (=*ferox*) and *P. cyanescens* have been reported to be suitable hosts. The latter two species occur in the United States. Certain members of the Muscidae and possibly ticks may also act as carriers.

PRECIS.

Out of 1600–1700 species of mosquitoes known from the world, of which a considerable percentage ingest human blood when opportunity is afforded them, less than 100 are important transmitters of human parasites. Yet these species easily outstrip all other insects combined in effect on human welfare. In the case of Malaria, anophelines are responsible for the spread of the most important disease of the tropics so far as morbidity is concerned and are probably indirectly involved in Blackwater Fever. Yellow Fever has been eliminated from many countries by "clean-up" campaigns against the larvae, yet there is the constant threat of reintroduction of the virus. In epidemics this infection becomes one of the most fatal diseases known, mortality ranging as high as 85% (averaging about 20%). Dengue Fever has been said to be "temporarily the most incapacitating, but least fatal of the epidemic diseases." Many individuals harbouring filaria exhibit few pathological changes but when symptoms of elephantiasis arise in other unfortunate victims the disease assumes an added significance. *Dermatobia* infections are minor ailments when compared to the above-mentioned diseases, but if they become a personal matter their importance increases. In spite of our present day knowledge in regard to the rôle mosquitoes play as intermediate hosts of the above human parasites the apathy of the general public to anti-mosquito measures is appalling.

NON-BLOODSUCKING FLIES AS VECTORS OF PATHOGENIC MICRO-ORGANISMS.

W. B. Herms,
Professor of Parasitology,
University of California, Berkeley, Calif.

Although the title of this paper is in accord with accepted usage it is not altogether accurate since most of the species of flies that we shall consider *do* suck blood avidly when the opportunity is afforded them. Some of these flies as a matter of fact see to it that this urge for blood is satisfied—they are positively haematophagous in habit. This fact, then, would readily establish such species in the list of possible vectors of pathogenic blood-inhabiting micro-organisms of man and other vertebrated animals. I shall revert to a consideration of this matter later in this paper.

A discussion of non-bloodsucking flies generally resolves itself into a discourse on the common housefly, *Musca domestica*, granted the fact that it is perhaps the most important species in relation to our subject as we shall see in spite of our desire to avoid overstressing an already threadbare subject. Although the family Muscidae will furnish us with much excellent material, there are also the families

Calliphoridae and Sarcophagidae to be drawn from and in order to avoid taxonomic pitfalls I shall perhaps obviously avoid placing some of the species mentioned into any family at all. In addition to these three families there are the Chloropidae and Anthomyidae which contribute to the interest of our subject. All students concerned with the study of flies and disease will, of course, be familiar with the excellent work of G. S. Graham-Smith on the "Non-Bloodsucking Flies" (Cambridge Public Health Series, 1913).

Prejudice against flies has existed literally for centuries. Apparently as early as about the fourteenth century B. C. flies were looked upon as of sanitary importance if the following quotation from Mosaic writings is correctly interpreted, viz.: "And there came a grievous swarm of flies into the house of Pharoah, and into his servants' houses, and into all the land of Egypt and the land was corrupted by reason of the swarm of flies." It is quite likely that some of the plagues striking both humans and cattle were attributable to these swarms of flies. As early as 1577 the manner in which flies carry infection, i.e., by food contamination, was correctly expressed by Mercurialis and about 1666 Sydenham expressed the belief that if houseflies are abundant in the summer the autumn will be unhealthy. In 1769 Bancroft advanced the theory that yaws was transmitted by flies.

Although much circumstantial evidence had accumulated against flies as carriers of disease long prior to the announcement of the germ theory by Pasteur in 1877–1881, the first microscopic evidence was not forthcoming until 1869 when Raimbert isolated the germ of anthrax from flies experimentally exposed to the cadavers of animals dead of anthrax. Raimbert also inoculated a guinea pig with a proboscis, two wings and four legs of a fly, and a second one with a wing and two legs resulting in the death of both animals. In 1886 Tizzoni and Cattini isolated virulent germs of cholera from flies caught in hospital wards in Bologna. According to L. O. Howard, Leidy in 1871 believed that houseflies were responsible for the spread of hospital gangrene during the Civil War. It was not until the Spanish American War (1898) that the real menace of the fly became evident as indicated by the following quotation from an article by Veeder in the Medical Record of September 17, 1898, viz.: "To clinch the argument, and apparently to leave no loophole for escape, I have made cultures of bacteria from fly tracks and from the excrement of flies, and there seems to be not the slighest difficulty in so doing. Indeed, the evidence of every sort is so clear that I have about reached the conclusion that the conveyance of infection in the manner indicated is the chief factor in decimating the army."

The following quotation from routine orders (16 April 1917) concerning sanitation in the operations of the Fourth Army (British) is indicative of the importance in which fly control was held during the Great War. "It must be impressed upon all ranks that their comfort and immunity from preventable disease will depend upon the cleanliness of their surroundings, and more especially upon the destruction and non-accumulation of all matter which can attract, or afford a breeding place for flies."

In the early days of anti-housefly propaganda more than twenty years ago the number of "germs" carried by this insect was threatingly held up to the public as an incentive to "swat-the-fly" campaigns. The higher the germ count provided by the bacteriologist, the more powerful was the lever of public opinion against the fly. As the number rose from 550 to 6,600,000 and then to 500,000,000 for flies from congested areas, so rose enthusiasm by leaps and bounds.

A very excellent and significant study along the lines of germ population has recently been made by Yao, Yuan and Huie (Nation. Med. Jour. China, vol. 15, no. 4, pp. 410–418, 1929) for Peiping, China. Their studies are based on a total of 384,193 flies of which 98.4 per cent were *Musca domestica*, 1.1 per cent *Fannia canicularis* and *F. scalaris*, 0.31 per cent *Lucilia caesar*, 0.16 per cent *Calliphora erythrocephala* and *C. vomitoria*, and 0.03 per cent *Sarcophaga carnaria*. They found an average of 3,683,000 bacteria per fly in the slum district, and 1,941,000 for the cleanest district. They found eight to ten times as many bacteria in the inside of the flies as on the outside. *Bacillus coli* was found in 49 out of 50 batches of 100 flies tested and *Bacillus dysenteriae*, in 15. *Bacillus typhosus*, *B. paratyphosus* and *Vibrio cholerae* were not found. They found from external washings cysts of flagellates, ciliates and *Entamoeba coli*. Alimentary tracts of flies revealed cysts of *Endolimax nana*, *Entamoeba coli* and *Entamoeba dysenteriae*. The specific death rate from gastrointestinal diseases paralleled roughly the number of flies captured.

Faichnie (Jour. Med. Assoc. So. Afr., vol. 3, no. 23, pp. 669–675, 1929) in a recent study of the etiology of enteric fever comes to the conclusion that comparatively little typhoid is carried on the feet of flies, but he found that both *Bacillus typhosus* and *B. paratyphosus* A multiplied in the intestines of flies fed on infected excrement. He also found that the fly larvae serve as efficient typhoid carriers.

In their study of the epidemiology of cholera, Gill and Lal (Indian Jour. Med. Res., vol. 18, no. 4, pp. 1255–1297, 1931) have found evidence to support the startling suggestion that possibly one phase of the life cycle of the cholera vibrio is passed in the body of the housefly. The results of their work show that the vibrios disappear from the body of the fly after about 24 hours but reappear on or about the fifth day, at which time the fly is capable of infecting food by its feces. Apparently this insect is not only a mechanical vector but may be involved in biological transmission.

Flies probably have little or nothing to do with the transmission of *Bacillus pestis* of plague, but it has long been known that the larvae of flesh flies feeding on dead plague rats carried in their bodies the organism of this disease: indeed it is believed by some workers without much supporting evidence, however, that flies reared from such infected larvae suffer a high mortality due to plague. Russo (reported in Rev. Appl. Ent. XIX, Ser. B, pp. 86–87, April, 1931) found that fly larvae taken from infected rats and pupae and adults reared from them all tested positively for the presence of plague bacilli. Plague bacilli were found in the dejecta of the adult flies. The species of

flies involved in Russo's investigations were *Musca domestica, Calliphora vomitoria, Sarcophaga carnaria* and *Lucilia caesar.*

What role if any flies play in the dissemination of *Bacillus botulinus* cannot well be conjectured because of meagre evidence and that in association with the larvae of carrion flies.

That flies may have some bearing on other bacillary food borne enteric infections traceable to *Bacillus paratyphosus* A and B is indicated by the experiments of Faichnie already referred to in reference to typhoid, i.e. multiplication of the organisms in the intestines of flies.

The relation of non-bloodsucking flies to the transmission of the causative organisms of such diseases as typhoid, paratyphoid, amaebic dysentery, and cholera is rather easily explained by the feeding and breeding habits of the involved species and the accessibility of the micro-organisms. Pathogenic organisms which readily retain their vitality when away from the host, particularly in dejecta attractive to flies are thus easily collected and deposited either mechanically or by regurgitation or defecation upon the food or drink of humans. It is largely a matter of food contamination.

That non-bloodsucking flies may also be factors in the transmission of diseases traceable to blood inhabiting parasites is a matter of record. How this is accomplished is better understood when the bloodthirstiness of these flies is fully recognized.

Freshly drawn blood, blood smears, etc., are pounced upon ravenously by houseflies. Suppurating and bleeding wounds are eagerly attacked by these flies. Most of us have observed little circles of houseflies surround a nervous Stomoxys fly boring for blood on the back of a cow or a horse. Due to much jostling the Stomoxys fly withdraws usually long before it has completed its meal and the hungry houseflies rush upon the liquid oozing from the still open wound made by the biting stable fly. Repeated performance of this type involving a change of hosts might readily result in the transmission of blood-inhabiting parasites. Indeed, Darling working in the Panama Canal Zone produced experimental evidence in 1912 to the effect that *Musca domestica* was able to infect a mule with Murrina, a disease traceable to *Trypanosoma hippicum.* Both horses and mules are susceptible to this disease and while Darling refers the infection to housefly contamination through attack on cuts and galls the method of infection above noted is obviously not excluded.

The liquids exuding from skin abrasions and ulcers, it may be repeated, are highly attractive to flies, hence such diseases as yaws characterized by ulcers of the skin caused by *Treponema pertenuis* may be readily transmitted by these insects. Castellani and others have experimentally proved this manner of infection, though it is believed that other methods of direct infection are of greater importance.

Although the common housefly, *Musca domestica*, apparently has a very strong predilection for blood, its close relatives, *Musca pattoni, M. gibsoni,* and certain others are said to feed almost exclusively on the blood and serum exuding from punctures made by the bites of other bloodsucking flies. As Root in his paper on "Parasitism among the Insects" (Sci. Mo., Nov. 1924) points out, ". . . . . the blood-

feeding habit has become well developed before any mechanism for piercing the skin and obtaining the blood is available."

HIPPELATES FLIES.

Hippelates flies of the Family Chloropidae (Oscinidae) have long been looked upon, particularly in certain parts of the southern United States, with suspicion in relation to a form of conjunctivitis commonly referred to as "sore eye," "pink eye," etc. A brief consideration of this matter is to be found in the Proceedings of the Entomological Society of Washington, vol. III, pp. 178–180,—a meeting held October 11, 1894, at which time E. A. Schwarz presented certain notes on *Hippelates pusio* in the Southern States. He stated that it was particularly abundant in Florida and annoying to man and animals, and that it is attracted to eyes and to the natural openings of the body as well as infected wounds. In this note as well as in a longer article in Insect Life for July 1895, Schwarz throws much suspicion on Hippelates flies as vectors of "sore eye."

For a number of years, at least since 1912, there have been numerous cases of catarrhal conjunctivitis apparently of the follicular type in the Coachella Valley of California where a veritable pest of Hippelates flies flourishes in season. Nowhere else in California are there such enormous numbers of these flies and nowhere else in the state do so many cases of so-called "pink eye" exist. We have published several papers dealing with this subject. (See Herms, Jour. Econ. Ent., vol. 19, no. 5, pp. 692–695, and vol. 21, no. 5, pp. 690–693; also Herms and Burgess, vol. 23, no. 3, pp. 600–603.)

The literature dealing with "The Oscinidae as Vectors of Conjunctivitis" has been recently reviewed with great care by Graham-Smith (Parasitology, vol. 23, no. 4, pp. 457–467, 1930). This review indicates a paucity of experimental evidence but a large amount of excellent circumstantial evidence involving Egypt, the West Indies, India, Ceylon, Java and the United States. In the same article above referred to Graham-Smith describes the mouth parts of several species of Hippelates flies and calls particular attention to six pseudotracheae with the tips of their chitinous rings upturned to form spines and projecting above the level of the pseudotracheal membrane. The author suggests that these spines apparently act as cutting instruments, capable of producing minute multiple incisions which are likely to assist infection with pathogenic organisms carried by these flies (Rev. Appl. Ent., vol. XIX, Ser. B, p. 60, Mar. 1931).

Nicholls (The Transmission of Pathogenic Micro-organisms by Flies in Saint Lucia, Bul. Ent. Res., vol. 3, pp. 81–88, 1912) in a discussion of the mechanical conveyance of germs by flies refers to *Oscinus pallipes* as the "ulcer fly" and cites an experiment in which he fed this fly upon pus from a boil caused by *Staphylococcus pyogenes* var. *aureus* and cultured the same from the fly 24 hours after it had fed. He also states, "I believe that the majority of cases of Yaws (framboesia) in the West Indies are caused by the inoculation of surface injuries by this fly. They feed only on the skin discharge of man and other animals, and though rare in the town of Castries, they are very numerous in

the country districts of St. Lucia, and can be seen hovering round the bare legs and arms of laborers, searching for abrasions or the secretions of the sweat and sebaceous glands." Nicholls' observation concerning the habits of these pernicious little flies is fully supported by our own experience with other species of Hippelates, "The persistence of these little flies is extraordinary; they must be brushed off by actually touching them and they will immediately return. If undisturbed, they engorge themselves with pus, blood, serum or sebaceous secretion, until their abdomens are greatly distended."

SUMMARY.

The ability of non-bloodsucking flies to transmit pathogenic micro-organisms is a matter that should challenge the attention of students of human welfare, particularly those responsible for sanitation. While the importance of this problem is far greater under tropical and sub-tropical conditions, it is of no little importance in temperate climates.

Where human feces are exposed to flies through ignorance or carelessness or force of circumstances there will always be the possibility of disease transmission. Vomits, sputum, exposed ulcers, suppurating wounds, bleeding wounds in the case of animals infected with certain diseases in which the blood is inhabited by pathogenic micro-organisms, conjunctival exudates as in so-called "pink eye," bodies of animals dead of plague, all offer sources of food for flies and in some species their larvae, and in turn are foci of infection. Flies may play an important role in the transmission of the pathogenic organisms causing cholera, typhoid fever, dysentery, Yaws, anthrax, ulcers.

The common housefly, *Musca domestica*, because of its very wide distribution, its fecundity, feeding habits and in a lesser degree its breeding habits, may play a leading role in the mechanical transmission of pathogenic micro-organisms, but there are other non-bloodsucking flies which may take rank with the housefly or even exceed it in rank under a different environmental set-up. Carrion flies such as the green bottles (*Lucilia* spp.), the blue bottles (*Calliphora* spp.), and the flesh flies (*Sarcophaga* spp.), may be highly important under plague or anthrax conditions in the presence of animals dead of this disease, as well as under conditions of cholera and typhoid since human excreta is favorable to their development as well as to their desire for food. Other non-biting flies of more local distribution and in a more specialized manner contribute to the spread of disease; among these are particularly the Hippelates flies in their relation to conjunctivitis.

The correction of this situation is to be found largely in putting into effect the measure of knowledge already at hand. A more generally informed, cooperative public will go a long way toward the solution of many of our problems in sanitation. Much of the trouble can be attributed to man's stupidity and ignorance. Ignorance of the facts, inconclusive and fragmentary evidence contribute not a little to the danger of this situation. Backwardness in promoting the evidence is not only due to the difficulty of the problems involved, but also to the noisome and loathsome materials which are involved in this type of study. Even parasitologists may be guilty of selecting the lesser evil in the realms of noisome subject matter.

DISCUSSION OF SYMPOSIUM PAPERS.

ERNEST CARROLL FAUST,
Professor of Parasitology, Dept. of Tropical Medicine,
Tulane University, New Orleans, La.

In discussing the papers presented at the symposium Dr. Ernest Carroll Faust of Tulane University, New Orleans, said: "While the scourge to human life from the transmission of disease by insects has been greatly reduced and ameliorated since the beginning of the century, bloodsucking insects are still one of the most important sources of human disease, particularly to non-immune populations. As a recent popular writer has expressed it, the stars may shape your destiny, or a mosquito bite may end your troubles and your dreams. We still have with us at one place or another on this earth malignant malaria, yellow fever, dengue, the trypanosomiases, leishmania infections, the rickettsial diseases, the filariases and other scourges to civilization, just as definitely as they existed two thousand years ago.

"While myiases are much less important in civilized communities than they are in native populations, it must be remembered that in China, India and in parts of the Tropics there are vast stretches with congested populations which are still subject to disfigurement and death from attacks of dipterous larvae. This is especially true at times of war, flood and famine, when large numbers of individuals are unable or do not have the vitality to protect themselves from such mutilation. Mr. Bishopp's presentation is therefore a relevant topic for consideration.

"Perhaps I may be pardoned if I add a few details to Dr. Schwardt's valuable paper. *Phlebotomus papatasii* and *P. sergenti* have been incriminated by Alder and others as transmitters of Oriental sore, caused by *Leishmania tropica*. *P. argentipes* in India and *P. major* in China have been found satisfactory experimental hosts of kala azar, caused by *Leishmania donovani*. In the insect host these oval or pyriform bodies metamorphose into Crithidia-like flagellated protozoa just as they do in culture. It is altogether likely that the mucocutaneous leishmaniasis of South and Central America, caused by *Leishmania braziliensis*, will be found to be transmitted by a species of Phlebotomus.

"In the Cameroons of Africa Sharp (1928) has incriminated the chironomid, *Culicoides austeni*, as the intermediate host of the persistent filarial worm, *Acanthocheilonema perstans*. The related form, *C. grahami*, is also circumstantially convicted. Other species of punkies probably serve in this capacity in Tropical America.

"Among the black flies the species *Simulium damnosum* has been shown by Blacklock (1926) to be the intermediate host of the convoluted filarial worm, *Onchocerca volvulus*, while the more recent work of Strong and of Ochoterena (1930, 1931) have indicated that three

species of the genus Eusimulium, *E. mooseri*, *E. ochraceum*, and *E. avidum*, have a similar function in the propagation of Coastal erysipelas, caused by the nodular worm, *Onchocerca caecutiens*.

"In passing, the important role which the tabanid, *Chrysops discalis*, plays in the transmission of tularaemia, and that of *C. dimidiatus* and *C. silaceus* in the life cycle of the loa worm, must not be overlooked. Nor should species of Chrysops and of Tabanus be left out of consideration when trypanosome infections of domestic animals are brought into the picture. In this latter group of infections both the mechanical and the more important physiological role need more attention than has been previously devoted to them.

"It is interesting to note that whereas muscid flies of the genus Glossina transmit the two African types of human trypanosomiasis as well as the related nagana of domestic animals, a bug, *Triatoma megista*, is the intermediate host of South American trypanosomiasis or Chagas disease.

"In considering the mosquitoes in relationship to disease transmission, it is difficult to add to the excellent resumé which Dr. Hinman has prepared. I can only refer to the ever increasing list of anophelines which are being found to be good definitive hosts of malaria, as carefully controlled experimental work is being done in various parts of the world. The recent investigations of the Japanese in Japan and Formosa and of the Dutch in Sumatra have made our laboratory findings more nearly tally with epidemiological data on dengue, particularly in showing that *Aedes albopictus* is a good transmitter of the virus. Furthermore, additional experimental study has added to the list of culicid intermediate hosts of Bancroft's filarial worm, *Wuchereria bancrofti*. Most important of all, however, has been the brilliant work of Johannes Bauer and Cornelius Philip in Africa (1928, 1931) and of Davis and Shannon in South America (1931), in incriminating several culicines other than *Aedes aegypti* as transmitters of yellow fever. Thus in the transmission of some of the most deadly human diseases, chapters which were thought to have been closed several years ago, have been rewritten to the lasting credit of the present generation.

"In a consideration of the role of non-bloodsucking flies in the transmission of disease, which Dr. Herms has so ably discussed, the protozoan and helminth infections are less likely to interest the epidemiologist and public health worker than are the more common epidemic bacterial infections. However, epidemics of amebic dysentery are not infrequently associated with the excess breeding of house flies in the tropics and the Orient. All flies breeding in human filth are potential vectors of Ascaris, whipworm, and pinworm infections. *Musca domestica* is also known to be the intermediate host of the chicken tapeworm, *Choanotaenia infundibuliformis*, while the bloodsucking stable fly, *Stomoxys calcitrans*, is the intermediate host of the common chicken tapeworm, *Hymenolepis carioca* (Guberlet, 1916).

"In fine, insects are still one of the most important sources from which man contracts disease."

THE LIFE HISTORIES OF TWO HORSE-FLIES.[1]

H. H. SCHWARDT,
University of Arkansas.

Biological studies on *Tabanus atratus* and *Tabanus trimaculatus*, carried on during the period 1929–1931 at Fayetteville, Arkansas, are reported upon in this paper. Supplementary field observations have been made at the Rice Branch Experiment Station near Stuttgart, Arkansas. Data are given on all the life stages for both species, except the preoviposition period for *T. trimaculatus*.

Tabanus atratus Fabr.

The black horse-fly, *Tabanus atratus*, is distributed over most of the United States west of the Rocky Mountains, and its range extends into Mexico and the West Indies. It is uncommon in the northern states, but fairly numerous from the latitude of Ohio and Kansas southward to the Gulf. In Arkansas it occasionally becomes abundant enough to interfere noticeably with the feeding of cattle. Four to six flies are often seen worrying a single animal. The low pitched ominous buzz of this fly seems to annoy cattle more than its bite.

Brief observations on the life history of *Tabanus atratus* have been published by several authors. Walsh (8) collected several larvae and reared one to the adult stage. Hine (4) determined the incubation period to be 9 days for a mass kept in the laboratory. Hart (2) found the egg period to be about a week, and discovered the egg parasite, *Phanurus tabanivorus*, which was described by Ashmead. The same author reports collecting the larvae during every month of the year except June. Stone (7) reared one individual from egg to adult in a period of 357 days, and obtained one adult from a collected larva. The pupal periods thus obtained were 11 and 14 days respectively.

REARING METHODS.

The technique used for rearing this species was almost identical with that used for *T. lineola*, which is described in a recent paper (6).

[1]Research Paper No. 263, Journal Series, University of Arkansas.

The only difference was in the treatment of pupae. Larvae when nearly ready to pupate were placed in soil about four inches deep. This appeared to be a more favorable medium for the pupae, but several developed satisfactorily in damp sand.

EGG.

In common with most Tabanidae, *T. atratus* deposits its eggs in masses which are so constant in structural plan as to make specific determination of the egg mass readily possible. Hart's (2) description of the egg mass is as follows:

"Blackish-brown, subconic, with oval base, 10–15 mm. long and 8–10 mm. wide, height 5–7 mm.; sides convex or concave, apex correspondingly rounded or pointed; eggs pointing obliquely upward and towards one end, both sides meeting upon that end in a more or less prominent longitudinal crest. The eggs are stacked in four or five tiers, one above another, and gummed together into a firm mass."

The masses are placed on low-growing vegetation at the water's edge, or in the absence of this on sticks or other objects projecting above the water or mud. They are white when newly deposited, but become gray or black within twenty-four hours. Cage oviposition has been obtained on young rice plants. Six masses from which the eggs were counted contained 724, 619, 555, 385, 420, and 649 eggs respectively. Individual eggs are elongate, taper toward both ends, and measure approximately 2.31 mm. long and .42 mm. wide.

INCUBATION PERIOD.

Under laboratory conditions, Hart (2) found the incubation period of *Tabanus atratus* to be 7 days, and Hine recorded a period of 9 days. In Arkansas, egg masses kept in an insectary where outdoor conditions were closely approximated, have hatched in a quite constant period of 5 days. Numerous masses of unknown age, collected in the field, have always hatched within 4 days.

LARVA.

Recently hatched larvae of *T. atratus* are white and pointed at both ends. They molt almost immediately after hatching. After the third molt conspicuous dark brown markings appear at each intersegmental area, and are retained throughout the larval period. The larva has been described by several writers. Stone (7) describes both the newly hatched and the full grown larva.

Larvae can be collected at any time of the year within the range of the species. They occur most frequently in mud near small streams or ponds, but have been taken from floating algae in irrigation canals, from under moss on stones, and in recently drained rice fields. Walsh took larvae of this species from rotting logs. In the latitude of northwest Arkansas, larvae have been taken every month in the year. They are fairly resistant to low temperatures, having been taken in an active state from the border of a pond thinly covered with ice. A few larvae

accidentally exposed to a temperature of 26° F., which froze the sand of their cages, appeared to suffer no inconvenience, and lived to produce adult flies.

LARVAL PERIOD.

The larva of *Tabanus atratus* usually hibernates one winter before producing the adult, but this is not invariably true. From a series of larvae which hatched June 20, 1930, four entered the pupal stage during the following August. The flies which emerged shortly after were of normal size and both sexes were represented. For twenty-four larvae reared from egg to adult, the period varied from 49 to 410 days. The average duration was 280.8 days. Rarely, a larva may pass two winters before pupating. A nearly full grown larva collected in February, 1930, lived and fed normally until the summer of 1931, when it died.

TABLE I.

Tabanus atratus Fabr. Number and Duration of Larval Instars. Fayetteville, Arkansas, 1930–1931.

	Duration of Instars in Days							
First instar	Second instar	Third instar	Fourth instar	Fifth instar	Sixth instar	Seventh instar	Eighth instar	Ninth instar
1—	8	6	6	8	36	.....	.....	.....
1—	4	4	6	4	8	8	24	.....
1—	4	4	4	6	2	6	8	28
1—	8	12	6	6	3	14	.....	.....
1—	3	5	4	6	10	313	.....	.....
1—	11	12	6	16	253	.....	.....	.....
1—	7	4	6	4	4	6	14	285
1—	7	8	8	4	8	10	29	253
1—	7	22	6	16	263	.....	.....	.....
1—	7	10	6	8	14	264	.....	.....
1—	7	12	6	8	18	275	.....	.....
1—	11	6	8	8	15	245	.....	.....
1—	21	6	6	15	257	.....	.....	.....
1—	21	6	8	290	.....	.....	.....	.....

NUMBER AND DURATION OF LARVAL STAGES.

Both the number and the duration of the larval stages are subject to a considerable variation. From five to nine larval stages have been observed, and these vary in duration from less than a day for the first instar to 313 days for the last instar. As has been observed by Stone (7), the first molt occurs very soon after hatching, so that the first instar invariably has a duration of less than one day. The number and duration of the larval instars for 14 larvae are shown in Table I.

PUPA AND THE PUPAL PERIOD.

The pupa of *Tabanus atratus* is of the usual tabanid type. It has been described by Hart (2), Hine (4), and Stone (7).

Since numerous field collected larvae have been reared to the adult stage, more data have been obtained for the pupal period than for the larval period. For 74 pupae on which observations have been made, the period varied from 6 days in midsummer to 40 days in early spring (Table II). The average duration was 13.3 days. The 40-day pupal stage was obtained for an individual which pupated during a warm period in early April. Cool weather followed for nearly a month, and was probably responsible for the unusually long time spent in the pupal stage by this fly.

TABLE II.

Tabanus atratus Fabr. Duration of Pupal Period.
Fayetteville, Arkansas, 1930–1931.

Pupal Period (Days)	Number of Pupae	Pupal Period (Days)	Number of Pupae
6	1	14	5
9	2	15	9
10	5	16	4
11	16	17	4
12	11	18	4
13	12	40	1

Average pupal period.....13.3 days

The pupa has seldom been found under natural conditions, but emerging flies were observed on one occasion. On May 30, 1931, while walking along a levee in the Arkansas rice-growing district, the writer noticed that specimens of *T. atratus* arose from the crown of the levee frequently. By proceeding more cautiously, ten flies were approached and captured. Within three inches of each was a pupal case in an upright position, with only the anterior one-fourth of its length about the surface. Since digging into the levee would have damaged it seriously, it was not advisable to determine from what depth the pupæ had worked, or what course they had taken to reach the surface. Rice field levees, since they contain almost a complete moisture gradient, probably are a favorite larval and pupal habitat for the Tabanidae which infest rice-growing areas.

ADULT.

The adult of *Tabanus atratus* is one of the larger North American horse-flies. It varies in length from 22 to 28 millimeters. The entire body, including the wings, is black, except for occasional specimens which have small hyaline areas in some of the wing cells. The frontal calosity is wider than high. This feature distinguishes *T. atratus* from the similar appearing *T. wiedemanni*, which has a square calosity.

PREOVIPOSITION PERIOD.

Because of the difficulty of inducing reared flies to feed, the preoviposition period was obtained for only one individual. A female fly which emerged July 11 was placed in a small cage with a freshly emerged male. A full meal of blood was taken July 14, and on July 19, which was eight days after emergence and five days after the first feeding, a complete egg mass was deposited. This fly fed again on July 21, but died the following day. The egg mass failed to hatch, probably because of infertility. Mating, if it occurred, was not observed.

TOTAL DEVELOPMENTAL PERIOD.

The average total developmental period, as obtained from the averages for the duration of the egg, larval, pupal, and preoviposition periods, is 307.1 days. If the minimum time is taken for each stage, total development can be accomplished in as few as 68 days.

NUMBER OF GENERATIONS.

Tabanus atratus is for the most part single-brooded. Eggs deposited in June have produced flies by late August, which could deposit eggs for a second generation. Egg masses have been collected in the field as late as September 29. A marked increase in the number of adults sometimes occurs in August and September, which may be due to the emergence of first generation flies. It seems likely that very few if any individuals require more than one winter of hibernation. Larvae of many sizes can be collected early in the spring, but these nearly always produce adults during the following summer. A single larva out of a large number which have been reared or collected, lived over two winters, but died before pupating.

Tabanus trimaculatus Palisot de Beauvois.

Tabanus trimaculatus is found principally in the eastern and southern United States. Its range extends north to Pennsylvania and west to Kansas and Oklahoma. It is usually rare in Arkansas, but occasionally becomes common for short periods.

The life history studies briefly presented here include records of observations on all life stages except the preoviposition period. Seven individuals have been reared from egg to adult, and ten from egg to pupa or adult. Twenty records for the pupal period have been obtained, and the incubation period has been determined. The life history of this fly is for the most part similar to that of *Tabanus atratus*.

The literature contains few records on the life stages of *T. trimaculatus*. Hine (3) found that egg masses of this species

commonly contained 500 eggs. Brimley (1) bred an adult from one of two larvae taken under the bark of a soggy log near water. The larvae were collected April 15, and the adult emerged May 18. Jones and Bradley (5) collected several larvae from beside brooks or ponds in November and December. These pupated during the following April and adults emerged after a pupal period of 8 to 15 days.

EGG AND THE INCUBATION PERIOD.

Eggs of *T. trimaculatus* are usually deposited on low-growing vegetation at the water's edge. One egg mass was collected from the under side of a sycamore leaf six feet above the edge of a pond. Two egg masses collected immediately after deposition each required six days for incubation. Three masses, from which the issuing larvae were counted, gave rise to 350, 350, and 413 larvae, respectively.

TABLE III.

Tabanus trimaculatus Palisot de Beauvois. Duration of Life Stages. Fayetteville, Arkansas, 1930–1931.

Incubation Period (Days)	Duration 1st larval stage (days)	Duration 2nd larval stage (days)	Duration 3rd larval stage (days)	Duration 4th larval stage (days)	Duration 5th larval stage (days)	Duration 6th larval stage (days)	Duration 7th larval stage (days)	Duration 8th larval stage (days)	Total duration larval period (days)	Pupal Period (Days)
6.....	1—	4	13	8	332	.....	.....	.....	358	9
6.....	1—	4	5	6	6	11	274	.....	307	12
6.....	1—	12	5	6	2	8	11	320	365	Died as pupa
6.....	1—	15	14	14	22	276	.....	.....	342	13
6.....	1—	17	6	20	18	297	.....	.....	359	9
6.....	1—	9	3	7	6	8	22	299	355	9
6.....	1—	4	11	6	12	10	20	294	358	8
6.....	1—	4	8	5	10	2	6	322	358	Died as pupa
6.....	1—	9	6	8	4	6	315	.....	349	Died as pupa
6.....	1—	17	8	8	11	17	301	.....	363	8

LARVA AND THE LARVAL PERIOD.

Newly hatched larvae are 2.10 mm. long and .31 mm. wide. They are white and remain so throughout larval life.

For the ten larvae observed, the larval period varied from 307 to 365 days (Table III). The average duration was 351.4 days. The larvae molt within a few hours after hatching, and at irregular intervals during larval life. From five to eight larval instars occurred, the last always occupying the greater part of the larval period, since it included the time spent in hibernation.

In the field, larvae always have been taken near the borders of ponds or small streams. Fresh and stagnant waters seem to be equally attractive, since larvae have been taken commonly near both types.

PUPAL PERIOD.

The pupal period has been observed for 20 pupae obtained either from reared or collected larvae. The average duration for this stage was 11.1 days. Variations of from 8 to 16 days, probably due to variations in temperature, occurred. The pupa of this species has not been found in the field.

LITERATURE CITED.

(1) **Brimley, C. S.** 1911. Notes on the life-histories of Tabanidae. Ent. News 22: 133.
(2) **Hart, C. A.** 1895. On the entomology of the Illinois river and adjacent waters. First paper. Ill. State Lab. of Nat. Hist. Bul. 4, 242–247.
(3) **Hine, J. S.** 1904. Some economic considerations with reference to the Tabanidae. Gulf Biol. Sta. Rept., Bul. 2, 86–87.
(4) ———. 1906. Habits and life histories of some flies of the family Tabanidae. U. S. D. A. Bur. Ent. Tech. Ser. Bul. 12, (pt. 2), 19–38.
(5) **Jones, T. H.,** and **Bradley, W. G.** 1922. Observations on Tabanidae in Louisiana. Jour. Econ. Ent. 16: 307–312.
(6) **Schwardt, H. H.** The biology of *Tabanus lineola* Fabr. Ann. Ent. Soc. Amer. 24: 409–416.
(7) **Stone, Alan.** 1930. The bionomics of some Tabanidae (Diptera). Ann. Ent. Soc. Amer. 23: 261–304.
(8) **Walsh, B. D.** 1863. On certain remarkable or exceptional larvae, coleopterous, lepidopterous, and dipterous, with demonstrations of several species injurious to vegetation. Boston Soc. Nat. Hist. Proc. 9: 302–306.

ANALYSES OF THE STOMACH CONTENTS OF TWO SPECIES OF IDAHO LIZARDS, WITH SPECIAL REFERENCE TO THE FORMICIDAE

A. C. Cole, Jr.,
Ohio State University.

Little is known of the feeding habits of lizards in general and of *Uta levis* Baird and Girard (Cliff Uta) in particular. In southern Idaho this species is apparently exclusive to the hot dry rock ledges in the deep Snake River Canyon near Twin Falls. The Cliff Uta seems to be restricted to this type of habitat for it has never been found on the adjoining sandy semidesert. In such a rocky habitat it abounds in New Mexico, Arizona, and southern Utah. This is apparently the first record of its appearance in Idaho. According to Woodbury (2) no study has been made and no account published of the food of *Uta levis*. He believes it to be an insectivorous lizard. The data presented in this paper confirm his presumption.

Sceloporous graciosus graciosus Baird and Girard (Sagebrush Swift), due to its abundance in the sagebrush semidesert, has received some attention among investigators. Woodbury (2) presents brief notes concerning the relative percentages of insects and arachnids in its diet, and Knowlton and Janes (1) have published on the food of nineteen specimens taken in Utah.

Numerous individuals of both of the above species were collected from the rocky ledges in the Snake River Canyon near Twin Falls, Idaho. They were shot with a pistol containing 22 calibre crimped shells filled with bird shot. The stomachs were removed in the field and preserved for examination. Analyses of twenty-five stomachs of each species taken at random are presented in Table I. Table II lists the numbers and species of Formicidae (ants) found in the stomachs. The tables are self-explanatory.

From 19 stomachs of *S. graciosus graciosus* taken in Utah during September and October, 1930, Knowlton and Janes (1) list only 3 arachnids and all were spiders. The writer found spiders, mites, and a few ticks in both species of lizards, and one scorpion was removed from the stomach of a specimen of *S. graciosus graciosus*. Knowlton's and Janes' analyses

were made in the autumn while the writer's were made in early spring (March and April, 1932); this difference in season probably accounts for the differences in food habits.

TABLE I.

Stomach Contents of Twenty-five Specimens Each of *Sceloporous graciosus graciosus* Baird and Girard, and *Uta levis* Baird and Girard, Taken at Random.

Insects	Total Contents of *S. graciosus*	Total Contents of *U. levis*
Hemiptera:		
Lygaeidae	25	29
Pentatomidae	4	3
Nabidae	1	0
Homoptera:		
Cicadellidae	67	41
Aphididae	5	7
Lepidoptera:		
Noctuidae (larvae)	29	38
Other (larvae)	6	1
Diptera:		
(larvae)	2	0
Chironomidae	0	4
Coleoptera:		
Curculionidae	8	0
Scarabaeidae	18	13
Carabidae	9	4
Elateridae	9	4
Chrysomelidae	6	0
Tenebrionidae	0	1
Hymenoptera:		
Ichneumonidae	3	0
Formicidae	55	41
Other	2	1
Arachnids:		
Spiders	51	52
Mites	23	32
Ticks	1	5
Scorpions	1	0
Leaves, plant fragments, sand, and pebbles	√	√

It is of interest to note that the bulk of the Formicidae ingested by *Uta levis* consisted of *Lasius niger americanus* and *Pogonomyrmex occidentalis* whereas only one of the former

and none of the latter were found in the stomachs of *S. graciosus graciosus*. The ant food of the Sagebrush Swift consisted chiefly of workers of *Crematogaster lineolata*.

Common to both species of lizards were Lygaeidae, Cicadellidae, Noctuidae (larvae), Formicidae, and Arachnida; whereas Nabidae, Chrysomelidae, Curculionidae, dipterous larvae, Ichneumonidae, and Scorpionidae were found only in the stomachs of *S. graciosus graciosus*, and Chironomidae, Hydrophyllidae, and Tenebrionidae only in *Uta levis*. The Lygaeidae consisted mostly of *Lygus praetensis*, and the Cicadellidae of species of Empoasca, Typhocyba, Agallia, and Thamnotettix.

TABLE II.

The Numbers and Species of Formicidae Removed from Stomachs of Twenty-five Specimens Each of *Sceloporous graciosus graciosus* Baird and Girard, and *Uta levis* Baird and Girard.

Species of Formicidae	Total from *S. graciosus*	Total from *U. levis*
Lasius niger americanus	1	17
L. umbratus mixtus aphidicola	0	3
Formica subpolita	8	0
F. fusca var.	1	0
F. rufa obscuripes	3	3
F. neogagates neogagates	1	1
Crematogaster lineolata	32	0
Monomorium minimum	1	0
Solenopsis molesta	3	0
Pheidole sp.	2	0
P. vinlandica	2	0
Pogonomyrmex occidentalis	0	17
Leptothorax curvispinosus	1	0

Knowlton and Janes (1) state that plant fragments are probably accidentally ingested with the food of *S. graciosus graciosus*. The writer is inclined to disagree with this statement inasmuch as he found whole leaves in the stomachs of some of the specimens, sometimes with the petioles still attached to the blades. Part of a bird's feather was found in the stomach of one individual, and sand and small pebbles were not uncommon in both species of lizards.

LITERATURE CITED.

Knowlton, G. F., and **Janes, M. J.** "Notes on insect food of two Utah lizards." *Utah Acad. Sci.*, VIII, (1931), 140–142.

Woodbury, A. M. *A descriptive catalogue of the reptiles of Utah.* Bull. Univ. of Utah, XXI, (1931), 1–129.

BIOLOGY OF SAROTHROMYIA FEMORALIS VAR. SIMPLEX ALDRICH.

(Diptera, Calliphoridae.)

DAVID G. HALL, JR.,
Division of Insects Affecting Man and Animals,
Bureau of Entomology,
U. S. Department of Agriculture.

The subfamily Sarcophaginae has an exceedingly interesting life history. Some of the species are parasites while others are scavengers and recently it has been found that some are able to adapt themselves to either environment. The following account concerns the biology of a subspecies belonging to a tropical or subtropical genus in which there has been but one species and one subspecies described. It is herein shown that this genus represents a new subfamily of Calliphoridae. Hitherto nothing has been published upon their habits or biology.

During the latter days of November, 1930, numerous females of a small grey sarcophagid were found upon the ocean beach at Charleston, S. C. Specimens were sent to Dr. J. M. Aldrich, of the U. S. National Museum, and were identified by him as *Sarothromyia femoralis var. simplex* Ald. (1). The species was known previously only from southern Florida.

The adults were exceptionally active and wary and on account of their flying only a few inches above the beach and resting periodically upon pebbles or sand, were usually difficult to obtain. The collecting seemed similar to that for some species of Miltogrammini.

Decaying beef left upon the beach by a high tide was found to be attractive to this species, and numerous gravid females were collected upon or near this material. At later times it was learned that decomposing crabs and fish above the high-tide line of the sea were also quite attractive to them.

The females of Sarcophaginae are supposedly viviparous. It is generally considered that they deposit active larvae upon or near material favorable for their development. When the abdomens of gravid females of this species were pressed it was found that only the first few larvae were ready for deposition, others being encased in a soft sac-like shell. When only

active larvae were extruded from a female and an interval of 10 to 20 minutes was given several more larvae could be obtained from the fly. Shortly after obtaining such larvae, additional pressure caused expulsion of larvae encased in the shells. Dr. Aldrich informs me that this phenomenon has been observed in *Sarcophaga securifera* Vill. by Dr. H. E. Ewing of the Bureau of Entomology.

As many as 3 larvae and 21 "eggs" were secured from one female at one time. Approximately half of these "eggs" hatched. The last few expelled in this lot did not contain fully developed larvae. The average number of both larvae and eggs obtained from a single female at one time was found to be 18.

Well decayed beef was found to be a good medium for development of the larvae. Several lots of larvae placed upon fresh beef did not grow so satisfactorily as when the meat was decomposed. Larvae were reared in such material on damp sand in petri dishes. They were kept under laboratory conditions at outdoor temperatures of about 60° to 70° F.

The larvae were active as soon as they were deposited and within a few hours after being placed upon the meat most of them could be found below the meat in the sand. When the meat was turned over or removed the larvae burrowed deep into the sand. Activity increased with development, and the migratory instinct was greatest just before pupation.

The average length of the larval stage was 334 hours, or approximately 14 days.

Pupae were kept under laboratory conditions in vials partly filled with damp sand. The pupal period in 57 individuals reared was from 34 to 41 days, the greatest emergence occurring after 36 and 37 days. Of the emerging adults, 28 were males and 29 were females.

Adults of the second generation were kept in large cloth-covered evaporating dishes and fed sugar and water. Both males and females lived for more than two months. Copulation was observed within eight hours after emergence of the female, but no larvae were obtained from the individuals observed to mate.

DESCRIPTION OF LARVA.

Larva (Fig. 4) pale yellowish white, tapering to a point anteriorly, truncate at posterior end. Segments 12, including head, of about

equal length. Chitinous spines formed by posterior edge of rugose lines very minute, light colored, and confined to segmental lines except in first and second instars. Posterior cavity (*pc.*) very shallow and indistinct, tubercles not defined; spiracular plate (Fig. 6) reddish yellow, separated by about one-half the width of one plate, each, except in first and second instars, with three slits. Below the spiracle the anal tubercles apparent in the last two instars only, widely separated, short and rounded. Numerous branched oral grooves (*og.*, Fig. 2) radiate toward the dorsal surface of the head from the oral opening where they unite on each side into semicylindrical chitinized structures that are approximated to form a funnel-like entrance into the oral aperture. Antennae (*ant.*) on each side of head near apex about as long as the diameter. Maxillary palps minute.

First-Instar Larva.—Length, 3–5 mm. Pearly white, all segments with indistinct rugosity medianly, the posterior edges of which are broken into numerous scale-like projections, especially on ventral surface of the second, ninth, and tenth segments. Metapneustic, the posterior spiracles located above a median line on the truncate end, with two entrances apparent. Buccopharyngeal apparatus very weakly developed, consisting of two large mandibular hooks articulated by a long slender rod solidly attached to a weakly developed basal piece which is paired and connected dorsocentrally.

Second-Instar Larva.—Length, 5–8 mm. The cuticular scale-like projections confined to the margins of the segments; an area of short, heavy, chitinous barbs just above the anal protuberances. Buccopharyngeal apparatus more heavily chitinized, articulated, equipped anteriorly with a pair of strong lateral hooks and attached together (Figs. 3 and 5) by means of a small median hypostomal sclerite (*hs.*) between the hooks and basal piece. Each plate is incised deeply posteriorly, forming a rod-like dorsal accessory piece (*dap.*); dorsal cornua in lateral view anteriorly drawn out. Posterior spiracles with two entrances.

Mature Larva.—Length, 8–15 mm. General form shown in Figure 4. Head (Figs. 1 and 2) with comparatively large antennae (*ant.*) and maxillary palps. Margins of each segment with rather coarse rugosity which occupies fully two-fifths of surface; amphipneustic, the anterior spiracles (*a. sp.*, Figs. 1 and 2) reddish brown, face shaped with eight rounded lobes. Larvae shortened, with rounded and segmented appearance. Buccopharyngeal apparatus (Fig. 3) with strongly chitinized and well-developed basal piece (*bp.*), the ventral surfaces of which have distinct longitudinal ridges (*lr.*). Posterior spiracles with "button" and three definite slits.

DESCRIPTION OF PUPA.

Pupa.—(Fig. 9). Length, 5–6 mm.; diameter, 2.5–3 mm.; light reddish-brown when first formed, growing darker before emergence of adult; segmentation indistinct. Spiracular plate (Fig. 7) in a very shallow depression on a median dorsal line on the truncated end, separated about half the width of one plate, each with a well defined

"button" and three slits, the middle about perpendicular, the outer two converging toward it ventrally; anterior spiracles (Fig. 8) dark, fan-shaped, with eight rounded lobes.

As given by Aldrich, the genus differs from all genera in Sarcophaginae in the peculiar shape of the head (Fig. 10), "the lower edge being very long and straight, the metacephalon built out behind in a lobe partially separated by a groove." The subspecies differs from the typical form only in lacking the peculiar erect hairs which form a fringe on the upper and outer sides of the fore tibia. Illustrations of the terminalia of the male (Figs. 11 and 13), and also the female (Fig. 12), are included to keep together the data on the biology of the subspecies.

According to DeMeijere (2), the so-called "button" is from the vestigial scar of the posterior stigmata of the first-instar larva. Root (3), shows indications of this character in his microphotograph of the posterior spiracles of *Sarcophaga lhermineri* Walker.

The presence of two spiracular slits in the first as well as the second stage larvae substantiates the work of Keilin (4), Johannsen (5), and others who have noted this character in the first-stage maggot of muscoid flies. The lack of a posterior cavity in the larvae and pupae, and the presence of a "button" on the spiracular plates of both the larvae and pupae of this species seem sufficient evidence to separate this genus from the main group of Sarcophaginae. A new subfamily name is therefore herewith given this segregate. Their food habits and general characteristics are those of the Sarcophaginae rather than the Tachinidae.

The Miltogramminae, another subfamily of the Calliphoridae also shows the presence of the "button" in the larvae and pupae, but a comparative study of the buccopharyngeal apparatus of these with Sarothromyinae shows little relationship.

The name of Sarothromyinae is herewith given to those species of the Sarcophaginae which show the above characters in the immature stages. The type genus is Sarothromyia and the type species is *Sarothromyia femoralis* Aldrich.

SUMMARY.

1. Sarcophagid females do not always deposit active motile living larvae but may, if the occasion presents itself, deposit larvae encased in a sac-like eggshell.

2. The first as well as the second instar larva of Sarothromyinae has two slits in the posterior spiracles.

3. The larva and pupa of Sarothromyinae do not exhibit the usual sarcophagid posterior cavity.

4. The larva and pupa of Sarothromyinae show a definite "button" on the posterior spiracular plates.

5. A new subfamily name (Sarothromyinae) is herewith proposed for the reception of the genus Sarothromyia.

REFERENCES.

(1) **Aldrich, J. M.** 1916. Sarcophaga and Allies, pp. 36-39. Lafayette, Ind., The Thomas Say Foundation of the Entomological Society of America.
(2) **DeMeijere, J. C. H.** 1894. Tijdschr. v. Entom. 38: 65–100.
(3) **Root, F. M.** 1923. Notes on larval characters in the Genus Sarcophaga. Jour. Parasit. 9: 227–229.
(4) **Keilin, D.** 1915. Larves de Dipteres Cychorhaphes. Bul. Sci. de la France, 49: 75.
1924. On a case of intestinal myiasis in man produced by the larvae of a Sarcophagid fly. Parasit. 16 (No. 3): 318–320.
(5) **Johannsen, O. A.** 1921. The first instar of *Wohlfartia vigil* Walker. Jour. Parasit. 7: 151–153.

EXPLANATION OF PLATES.

PLATE I.

Fig. 1. Head of *Sarothromyia femoralis* var. *simplex;* mature larva, three-quarters ventral view: *mp.*—maxillary palp; *ant.*—antennae; *og.*—oral groove.

Fig. 2. Head of mature larva, ventral view: *a. sp.*—anterior spiracles.

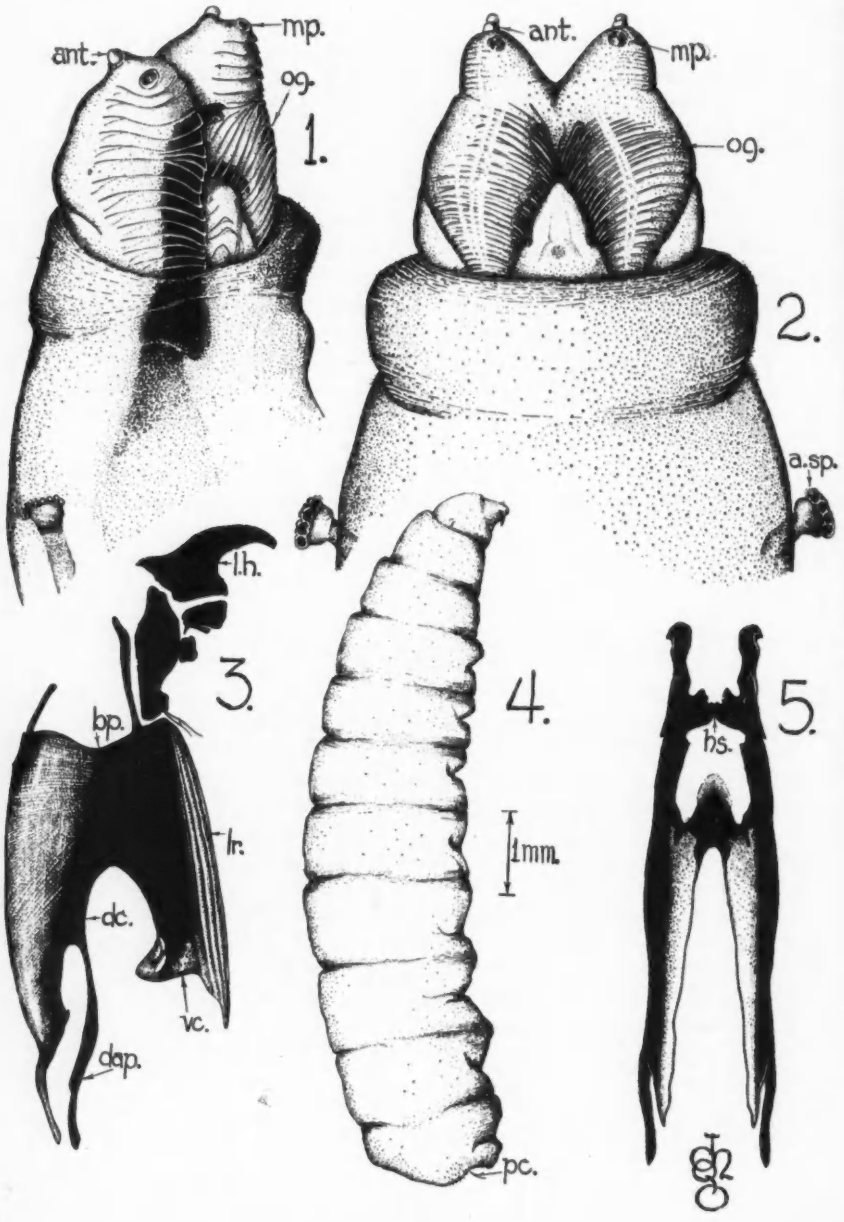
Fig. 3. Lateral view of buccopharyngeal apparatus of mature larva:
lh.—lateral hooks. *dc.*—dorsal cornua.
bp.—basal piece. *dap.*—dorsal accessory piece.
lr.—longitudinal ridges. *vc.*—ventral cornua.

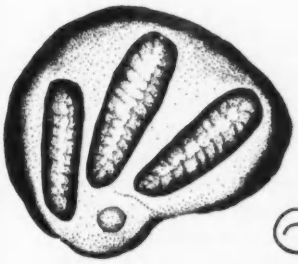
Fig. 4. Lateral view of mature larva: *pc.*—posterior cavity.

Fig. 5. Dorsal view of buccopharyngeal apparatus of mature larva: *hs.*—hypostomal sclerite.

PLATE II.

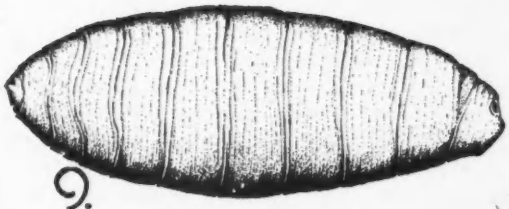
Fig. 6, Posterior spiracle of mature larva. Fig. 7, Posterior spiracle of pupa. Fig. 8, Anterior spiracle of pupa. Fig. 9, Lateral view of pupa. Fig. 10, Lateral view of female head. Fig. 11, Left lateral view of male hypopygium closed. Fig. 12, Posterior view of female terminalia. Fig. 13, Left lateral view of male hypopygium open.


ant.
mp.
og.
1.
ant.
mp.
og.
2.
a.sp.
l.h.
3.
bp.
lr.
dc.
vc.
dap.
4.
1mm.
pc.
5.
hs.



6.

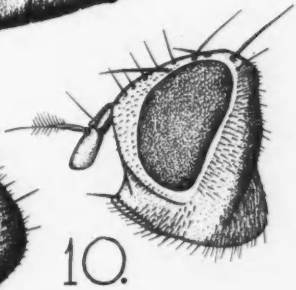
7.



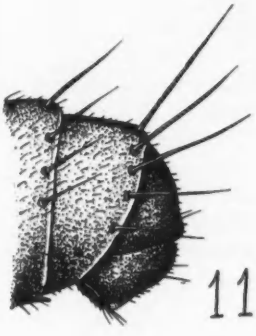
9.

8.

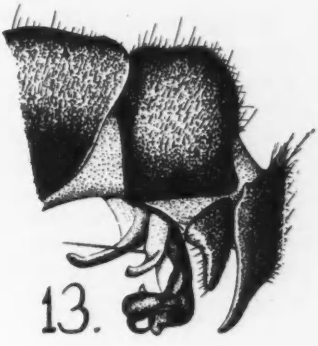
12.



10.



11.



13.

THE LIFE HISTORY AND THORACIC DEVELOPMENT OF OLIGOTOMA TEXANA (MEL.) (EMBIIDINA).

HARLOW B. MILLS,
Iowa State College.

During the spring and early summer of 1931 the author had the good fortune to discover in the vicinity of College Station and Bryan, Texas, a number of Embiids belonging to the species *Oligotoma texana* (Melander). A number of them were captured alive and kept in captivity in a vial for three months, and were killed then only because of the fact that it was impossible to longer care for them. No difficulty was experienced up to that time in keeping them alive, in fact they seemed quite hardy. During that time notes were taken concerning their development which are recorded in this paper.

College Station lies in the transition zone between the eastern Austro-Riparian and the southwestern Lower Sonoran faunal zones. It lies also near the dividing line between the *Pinus-Quercus* ecotone to the east and *Quercus-Carya-Andropogon* alternes to the west. To the east of the college ten miles or so one finds the post oak (*Quercus stellata*) mingling with tupelo and linden of the eastern flora. These trees disappear as one progresses westward and other plants, mesquite (*Prosopis*) for instance, which are characteristically southwestern, spring up to take their places. *O. texana* was taken in all of these regions.

Melander[1] has written rather extensive accounts of the history and habits of *Oligotoma texana*, and in general the observations made during the spring of 1931 agree with those made by him.

On March 15, while stripping bark from an old post oak log, the first specimens were taken, about forty in all. Some of these presented an odd appearance in that the meso- and metanota were reduced to triangles with the apices pointed posteriorly, with the posterolateral portions of these regions colorless, thinly membranous, and extending beyond the posterior margins of the meso- and metanota proper. These

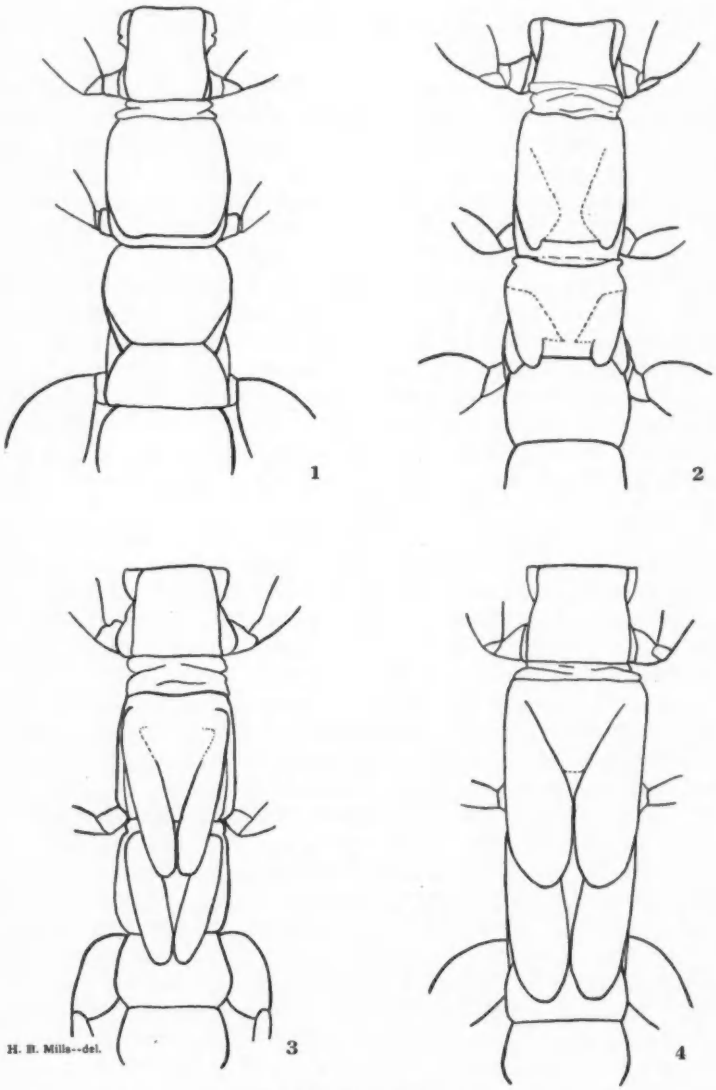
[1]Biological Bulletin 3: 16–26, and 4: 99–118.

were singled out as immature males, which they later proved to be. Half of the catch was kept alive in a loosely corked vial on a piece of rotting wood which they immediately covered with their webs. After a few days a cake crumb was dropped into the vial, and within thirty seconds Embiid heads appeared at the openings in the webs, followed by their slender brown bodies as they made their way toward the food. By the next morning the crum was completely hidden in a maze of silken tunnels which led from the rotting wood to it. Thereafter they were fed a diet of bread crumbs, and they always elongated their tunnels to include the food.

The males were examined periodically until they reached maturity and obtained functioning wings, between May 15 and 20. During this developmental period a number of striking changes were noticed in the development of external wing pads which will be noted later.

Other collections were made from time to time, in fact one was seldom disappointed in a search for these insects. The majority were found beneath bark, differing somewhat in habitat from the type series collected at Austin, Texas, by Melander, chiefly from beneath stones and in the soil. Two specimens were taken in Spanish moss by C. S. Siddal on March 20. On April 16 specimens were taken at Milano, about fifty miles west of College Station, by Prof. V. A. Little. At Easterly, about fifty miles northeast of College Station, specimens were taken from the bark of stumps on May 16. A female was captured at Millican, by H. J. Reinhard on July 19 from which two oval white eggs were procured on the two following days. Two females were taken at Bryan, July 26, with newly hatched young in the webs. The young were very light brown in color and semi-transparent. The food in the alimentary canal could be readily seen through the integument. The interest which the mother took in the young was notable. The little ones would crawl under, over, and about the mother, reminding one of a number of kittens playing about the mother cat.

There is apparently but a single generation of the species a year, the life history of which, in summing up the data above would be about as follows: The eggs are laid about the middle of July, the nymphs hatching therefrom overwintering, and becoming adults as early as May 15. The number of ecdyses,



Oligotoma texana (Mel.)

Fig. 1. Dorsal view of thorax of female, showing the completely apterous condition.

Fig. 2. Thorax of male from dorsal view, showing the origin of the wing pads. The part of the dorsum within the dotted lines is membranous and colorless, in contrast to the heavy, brown, median part.

Fig. 3. Thorax of male from dorsal view. Second stage in wing development.

Fig. 4. Thorax of male from dorsal view. The final stage in external wing development in the nymphal stage.

length of life stages, biology, etc., present interesting problems which remain to be solved.

A labial secretion was not seen to enter into the construction of the webs, the glands of the metatarsi apparently being the only source of silk. The process of web spinning is deeply interesting. The Embiid's enlarged metatarsi bear a great resemblance to a pair of boxing gloves, and as it swings them about in front of itself in spinning a web, it reminds one of a miniature prize-fighter shadow-boxing. As the feinting continues a fine haze is seen to appear in front of the spinner. Against a light background the fine web is all but invisible and, as the Embiid pushes out on it, it appears to be walking through space. By spinning as it slowly rotates on its long axis, the characteristic silken tunnel is produced. Within this tunnel it seems to pay no attention to gravity, being found as often as not with its ventral side upward. It moves with alacrity both forward and backward in the web. As it moves or hangs in the web, the first and last pairs of legs hook into the web naturally while the middle pair extends over the back, attaching to the portion of the tunnel which is just behind the dorsum; in other words, if the insect is standing in the tunnel with its ventral side down, the middle legs extend upward over the back, hooking into the silk above, but bearing little of the weight of the body. This may account for the comparative reduction in the size of the femora of the middle legs.

The thoracic modification of the males in the development of the wings has already been alluded to. The developing wings restrict the notum to a dorsal triangle, and extend slightly behind the posterior margin in the first stage (Fig. 2). These wing pads contrast with the chocolate brown notum in being white and membranous. As they develop they become semi-cylindrical and elongate, the tips meeting behind the posterior margin of the notum on which they originate (Fig. 3). At this stage two suffused brown lines appear near the lateral margins of the wings, very likely the forerunners of the brown lines which are found on each side of the R_1 vein in the fully developed wing. In the third stage in nymphal development (Fig. 4) the pads are flattened, and attached diagonally along the sides of the triangular nota.

If each of these stages represents a definite instar, we have a phenomenon here that is unique in the order of Embiidina.

It is usually stated in discussions of this group that the wings develop in invaginated pouches until the last nymphal instar when they appear as external pads. Melander has even found these internal pouches in young specimens of the species here discussed. It has been suggested that these different stages are all found in the same instar, that the change from an internal condition to an external one is gradual and lasts throughout the last nymphal instar. This is very possible but would seem improbable in the light of the fact that evidences of external wing pads were visible for two months in the spring and it is likely that there was at least one ecdysis before the final, when the adult was disclosed.

This phenomenon has been recorded before by Mr. R. C. L. Perkins[2] in 1897 for *Oligotoma insularis* McLach. from Hawaii but his results have been discredited by later writers who believed that the pads which he described were not homologous to the wing pads of the last nymphal instar. However, the series which was obtained last fall and which are figured in this paper would seem to demonstrate the correctness of Perkin's observations.

[2]Entomologist's Monthly Magazine, 1897, 56–58.

BOOK NOTICES

METHODS FOR THE STUDY OF THE INTERNAL ANATOMY OF INSECTS, by CLARENCE HAMILTON KENNEDY. 103 pages. Mimeographed by H. L. Hedrick, 254 E. Oakland Ave., Columbus, Ohio.

In a neatly mimeographed form, within a good paper cover, this is a book that every teacher who gives a course on insect anatomy or histology must many a time have wished he could have at hand. There is here condensed not only information for the student, but also, we may venture to say, for the instructor himself unless he is an adept in laboratory technique. In his FOREWORD the author says that his outline is prepared for a specific course on the internal anatomy of insects given at the Ohio State University. But such courses are not geographically limited to the State of Ohio, and though the matter may be aimed at one particular target, it will find its mark wherever teachers are struggling to impart standard working methods to beginning students, and again, we have the author's word for it that the text is written "for the beginner who starts with no knowledge of micro-technique." Beginning with the collection and dissection of fresh material the matter, by its nature comparatively simple, is amply handled in a few pages. Then comes the much more difficult field of study by use of the microtome, and under separate headings are treated such subjects as ordinary histological preparations, embryological technique, the problem of chitin, and intra-vitam staining. Numerous diagrams illustrate utensils, apparatus, and correct methods of mounting. A following section discusses more technical procedures, such as the use of special stains, imbedding in celloidin, double imbedding, injection of tracheae, and the study of specific organs and tissues. Next is a section on reagents, with formulae, and directions for use. Apparatus and tools, illumination, and care of the microtome razor then receive attention. Finally, the student is given many practical pointers on the making of drawings and the preparation of drawings for publication, with the sound advice that he *can* learn to draw, if he wants to do so, unless perchance he unfortunately belongs to a hopeless ten percent. A page of well selected bibliographical references completes the text. The book ends with an index of approximately 1,000 entries giving direction to items contained in the preceding 93 pages.—R. E. S.

LABORATORY AND FIELD MANUAL OF ECONOMIC ENTOMOLOGY, by JOHN R. EYER. 132 pages, mimeographed by Edwards Brothers, Inc., Ann Arbor, Michigan.

This volume contains the following exercises for student class work: Part I, seven exercises on anatomy and physiology, one on development and metamorphosis, and four on the classification of insects; Part II,

ten exercises on control methods by chemicals, one on cultural methods, one on quarantines and one on biological control; Part III, three exercises on the forms of entomological literature, and one, an outline for a term paper; Part IV, three exercises on collecting and rearing insects, general instructions for field trips and mounting and preserving insects. This body of the work is followed by thirty pages of "field keys" to the more common insect pests, one page of field study forms, and a twelve-page classification of the orders of insects based on feeding habits. There is an excellent table of contents but no index. The volume is essentially a classification of a diversified and exceedingly complicated subject. This feature should be of help to teachers of economic entomology. To the writer it lacks the thrills that intrigue the interest of students though few sciences can show the wealth of thrilling conquests credited to economic entomology. It is hard-boiled applied science.—C. H. K.

A NATURALIST IN THE GUIANA FOREST, by MAJOR R. W. G. HINGSTON, M. C. Published by Longmans-Green & Co., New York (Edward Arnold & Co., London), 384 pages with 150 text figures and 16 plates.

This volume is by the author of "Instinct and Intelligence," "A Naturalist in Himalaya" and "A Naturalist in Hindustan" and is descriptive of the work of the English expedition which explored the canopy of the rain forest of British Guiana. The staff included botanists, zoologists, and entomologists, who were equipped with various kinds of climbing apparatus for exploring the leafy top layer of these great forests. For the first time in tropical exploration the fauna of the upper surface of a rain forest was systematically studied. In sixteen chapters the volume describes the rain forest, the methods used in reaching the tops of the giant trees and the curious habits and activities of the animal life limited to this top stratum of leaves, of intense light, heat and moisture. "Here nature has run riot in its leafy fastnesses." The volume is limited to descriptions of the habits of those insects and spiders which interested Major Hingston personally and in it are given many curious and startling adaptations. While tending to teleological expression at times it is a fascinating book.—C. H. K.

TRAITÉ D'EMBRYOLOGIE COMPARÉE DÉS INVERTÉBRÉS, by C. DAWYDOFF, pp. I–XIV, 1–930, 508 figs., 1928. Published by Masson E Cie., 120 Boul'd Saint-Germain, Paris, VI.

We wish to call attention to this concise review of the embryology of invertebrates, a book which does not appear to be widely known in entomological laboratories in this country. Four hundred pages are devoted to the embryology of the Arthropoda and related forms, seventy-five of which are devoted to insects. Excellent, though not complete bibliographies accompany each chapter. Professor Dawydoff

was formerly at the Universities of Perm and Petrograd, but is at present resident in France. The volume gives the best review of the whole subject of insect embryology at present published.—C. H. K.

ANIMAL AGGREGATIONS, by W. C. ALLEE, pp. I–IX, 1–431, 35 figs., 1 chart, 1931. Published by The University of Chicago Press, Chicago, Illinois.

The estimation of insect populations and the analysis of the factors involved in various densities of population are among the most baffling problems that economic entomologists face. Any work which throws light on such problems is very welcome to workers in this field. "Animal Aggregations," by Allee, is a volume which carries a bibliography of forty-four pages of literature which deals with the subject directly and indirectly. The body of the text is a thorough review and sorting out of this mass of information much of which has been derived from Professor Allee's own research on animal aggregations. While touching on insect aggregations at many points in the discussion the work covers aggregations throughout the animal series so that the volume is given the subtitle "A Study in General Sociology." Professor Allee discusses the problems of aggregation as they appear from the lowest organisms, bacteria and protozoa, to the social insects and social vertebrates. He even relates them back to those factors which lead cells to aggregate into the tissues of the organic body.

The volume is divided into several series of chapters as follows: INTRODUCTION. Chapter I. The General Background. II. Classification of Animal Aggregations. III. Formation of Animal Aggregations. IV. General Factors Conditioning Aggregations and V. Integration of Aggregations; HARMFUL EFFECTS OF AGGREGATIONS, three chapters; BENEFICIAL EFFECTS OF AGGREGATIONS, eight chapters; GENERAL EFFECTS OF AGGREGATIONS, two chapters. Chapter XVII. Influence of Crowding upon Sex Determination. XVIII. Morphological Effects of Crowding; CONCLUSION. XIX. Animal Aggregations and Social Life. XX. The Principle of Co-operation.

The feature of the work which impresses the writer is Professor Allee's method of examining the problem. The problem of aggregation is the problem of a complex variable and practically all biological problems are of this nature. Some outstanding ones are parasitism, social life, etc. These start at an illy defined lower limit and evolve upward to a high degree of specialization. The earlier efforts of study gave us definitions of the highly specialized upper limits of each, treating such as constants by arbitrary definition. The more philosophical biologists recognize such phenomena as variables and seek out the lower limit before constructing a definition which when finally arrived at may put an entirely different face on the matter from that of the earlier definition applied hastily to the upper limit as represented in the highly developed or specialized form of the phenomenon. An analysis or a definition which includes both the lower and the upper limits of a

variable is of its very nature more nearly explanatory. Professor Allee attempts this broad and proper approach. He has been probably as successful as one could be in the present stage of development of biology. If for no other reason than that of a study of Professor Allee's approach to the problem, the volume should be read by every student of applied entomology. However, nearly every page suggests problems that sooner or later will be studied by entomologists dealing with insect populations.—C. H. K.